STEAM AND CHILLED WATER UTILITIES DESIGN GUIDELINES

(SCUDG)

YALE UNIVERSITY

May, 2009

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1. INTRODUCTION

A. PURPOSE OF THE DOCUMENT

This document, titled "Steam and Chilled Water Utility Design Guidelines (SCUDG)", shall be used by Yale employees and all engineers providing design and installation work for Yale associated with the steam, condensate, and chilled water utility systems as defined in the scope. The intent of this document is to express to all interested parties the current design and installation practices of the related systems. It is the responsibility of Yale employees and the engineers hired by Yale to incorporate these guidelines in their bid documents and enforce them so Yale can yield the benefits of these efforts. This document has been developed based on previous and current design, construction, and operation experiences. This document will be modified in the future for clarifications and to incorporate lessons learned from new experiences and to accommodate changes in policy and industry practices. Comments to this document are always encouraged for the benefit of future projects.

1. Limit of Scope

   a. This document provides design standards only, and is not intended for use, in whole or in part, as a specification or details on drawings. Do not copy this information verbatim in specifications or in notes on drawings.

   b. The design standards are not a substitute for a complete design. Yale assumes no liability for damage as a result of these documents. If a consultant or any other person identifies any potential health or safety issues, that person must address the issues in writing.

   c. These design guidelines are for the utility distribution systems that are in tunnels, direct buried piping, and trenches, that are located on Yale property and in the city streets. These guidelines also apply to major distribution piping that travel through buildings typically found in basements or crawl spaces. The design guidelines apply to buildings as well in consideration of pressure reducing stations, metering stations, and condensate return systems. The design guidelines do not apply to the HVAC systems of the buildings themselves. For the design guidelines for Capital Projects, refer to the Yale Utilities website at http://www.facilities.yale.edu/Work/Standards.asp. Designers for buildings are urged to read these guidelines to understand the steam and chilled water conditions being supplied to the buildings.

2. Administration of Document

   This document is published and administered by Yale University, Office of Facilities, Director of Utilities. Any questions, requests for deviation, or proposed modifications shall be addressed to the Manager of Distribution and Metering Utilities.

3. Yale Utilities

   In this document, the Manager of Distribution and Metering Utilities shall be considered wherever "Yale Utilities" is referenced. It is requested that all correspondence related to this document be put in writing to Yale Utilities. Any items specifically referencing metering shall be directed to Yale Systems Engineering. Deviations from this document are only allowed if the Yale Utilities has granted written permission.

B. GENERAL DESCRIPTION OF YALE STEAM AND CHILLED WATER DISTRIBUTION SYSTEM

1. General Background

Yale University is a university campus located in New Haven, Connecticut. The University, which is a historical center of undergraduate, graduate, and doctoral studies, consists of approximately 200 buildings. These buildings range in use from classrooms to student living and dining facilities to research laboratories, libraries, museums, and a hospital. The Yale buildings are located in two contiguous areas, a medical school campus and the Science Hill/Central campus. Each of the two areas contains a central district heating and cooling plant, which provides thermal energy in the form of steam and chilled water to many of the university buildings. The Science Hill/Central campus plant (hereafter referred to as the Central Power Plant or CPP) can provide up to 22.5 MW of electrical power for university loads. The medical school campus including the hospital is served by the Sterling Power Plant (or SPP).

a. Operations Responsibility

Operation and maintenance of the district plants is the responsibility of the Yale Utilities Department. The two district thermal plants, CPP and SPP are operated independently with Yale management responsible for both. This SCUDG corresponds to the distribution system associated with the CPP and the SPP.

2. CPP Distribution

Steam and chilled water are distributed from the CPP to three distinct areas as shown in Drawing Nos. 1 and 2. Refer to Yale Utilities for the available pressures of the systems. Definitions of HPS, MPS, and LPS are provided in Part 9. Active and planned projects are changing the pressures in the areas and providing redundancy, along with maintaining services to the various new and renovation building projects. Refer to Yale Utilities for any available updated drawings.

a. Cross Campus and Old Campus Areas:

1) Steam: Two 14” LPS pipes and two 10” HPS pipes serve this area via the Law School Tunnel from the CPP. The 12” LPS pipe serves the Hall of Graduate Studies and a 6” HPS branch pipe serves Morse College, Ezra Stiles College, Yale Book Store, and Mory’s Restaurant.
2) Chilled Water: 20” pipes serve this area which is also looped by a 14” pipe to/from the Science Hill area for redundancy.

b. Science Hill Area:

1) Steam: Two separate, redundant, direct buried 12” HPS pipes serve the Science Hill area.
2) Chilled Water: 24” pipes serve this area with redundancy from the Cross Campus / Old Campus area network as described above.

c. Payne Whitney Gymnasium and Associated Buildings:

1) Steam: One 8” HPS and one 14” LPS serve this area through a tunnel from the CPP.
2) Chilled Water: A 12” pipe serves this area.

3. SPP Distribution

SPP distributes HPS at 125 psig, LPS at 10 psig, and chilled water to the campus of the Yale School of Medicine and Yale/New Haven Hospital (YNHH) through three distribution tunnels: YPI, B-Wing and YML/C-Wing. YNHH is supplied through B-Wing tunnel. High pressure water for use in fire protection systems is also distributed to the campus and hospital from SPP. Refer to Drawing Nos. 3, 4, and 5 for the general configuration of the steam, condensate return, and chilled water utility routing. Refer to Yale Utilities for the available pressures of the systems. Definitions of HPS and LPS are provided in Part 9. Active and planned projects are changing the pressures in the areas and providing redundancy, along with maintaining services to the various new and renovation building projects. Refer to Yale Utilities for any available updated drawings.

a. YPI:

1) HPS is distributed to the YPI network through 8” and 12” steam mains. There is no LPS distribution through this tunnel.
2) Chilled Water is distributed through 24” Supply and Return legs.

b. B-Wing:

1) HPS is distributed to the B-Wing network through an 8” steam main. LPS is distributed through a 12” steam main.
2) Chilled Water is distributed through 30” Supply and Return legs.

c. YML/C-Wing:

1) HPS is distributed to the YML/C-Wing network through a 6” steam main. LPS is distributed through a 12” steam main.
2) Chilled Water is distributed through 12” Supply and Return legs. A branch distribution line feeds Brady/Lauder distribution using 10” direct buried Supply and Return legs.

d. YNHH:

1) HPS is distributed to YNHH through a 14” steam main through B-Wing tunnel.
2) Chilled Water is distributed from a branch circuit from B-Wing main.

2. TIE-INS TO CAMPUS DISTRIBUTION SYSTEM

A. COORDINATION

All connections to the campus steam, condensate, and chilled water systems shall be supervised, scheduled with, and coordinated with Yale Utilities. The Contractor shall notify Yale Utilities a minimum of 14 calendar days in advance of requested outage to perform a tie-in. Yale Facilities has final authority on any and all scheduling for connections. Steam and chilled water will only be admitted to a new connection when a University account has been established and meters have been installed.

B. PHASING RESTRICTIONS

Connections shall only be made when University operations permit an outage. Hot taps or wet taps are an acceptable means of connecting to the distribution system, but it is preferred that a system be connected during favorable weather conditions when the utility can be shut down (for steam, this will typically be when the ambient temperature is above 50 deg F and for chilled water when the ambient temperature is below 65 deg F). The hot tap or wet tap must be performed by qualified personnel who have equipment and experience with the activities and the procedure must be approved by Yale Utilities. Wet taps for chilled water can occur by freezing the pipe – this has been successfully performed on 24” piping.

3. DIRECT BURIED PIPING AND CONDUIT SYSTEMS

A. GENERAL

Direct buried piping systems shall be provided when dictated by Yale Utilities.

B. STEAM AND CONDENSATE SYSTEMS

1. Materials

a. All underground direct buried steam and condensate lines shall be Class A testable, drainable and dryable. The system supplier shall have fabricated systems of the composition described herein for at least three years. All straight sections, fittings, anchors, and other accessories shall be factory prefabricated to job dimensions and designed to minimize the number of field welds. Each system layout shall be computer analyzed by the piping system manufacturer to determine the stresses on the carrier pipe and anticipated thermal movement of the service pipe. The system design shall be in strict conformance with ASME B31.1. The pre-approved conduit system shall include all piping and components to a point as designated on the drawings inside the building, tunnel, or manhole wall. Manufacturers shall be Perma-Pipe (Multi-Therm 500) or Thermacor (Duo-Therm 505).

b. The system supplier’s representative shall be responsible for directing the installation and testing of the conduit system. It shall be certified in writing by the supplier that the representative is technically qualified and experienced in the installation of the systems and has been factory trained to provide field technical assistance. The supplier's representative shall be present during the following work phases:

   1) Inspection and unloading
   2) Inspection of trench prior to laying of conduit
   3) Inspection of expansion loops
   4) Inspection of joining of system
   5) Hydrostatic Testing (piping)
   6) Air test (conduit)
   7) Repair of any patchwork
   8) Back filling of conduit sections

c. The contractor shall not perform any of the above stated work in the absence of the system supplier's representative.

d. The contractor performing the work shall be responsible for the installation of the pre-approved system and all other components of the underground steam and condensate conduit systems, including the piping equipment in the manholes and buildings. This responsibility shall include all site work and purchase of the pre-approved system from the system supplier.

e. General Direct Buried Steam and Condensate System Specifications

   1) Service Pipe and Fittings Specifications: Refer to the Part 7 for all System

Specifications.

2) Service Pipe: Where possible, straight sections shall be supplied in 40 foot random lengths with 6 inches of piping exposed at each end for field joint fabrication. Systems with condensate lines 6 inches and smaller, shall have the trap return and pumped condensate piping contained in a single outer conduit pipe.
3) Sub-Assemblies: Gland seals, end seals, and anchors shall be designed by the system manufacturer and factory prefabricated to prevent the ingress of moisture into the system. Gland seals shall be used when thermal expansion is carried through the manhole wall as when an expansion joint is located inside the manhole. When an anchor is direct buried outside of the manhole, end seals shall be used. Make sure end seals and gland seals are called out on the drawings. All sub-assemblies shall be designed to allow for complete draining and drying of the conduit system. Refer to Detail 3-1, Link Seals, End Seals, and Gland Seals.
4) Piping Insulation: Piping insulation shall be mineral wool for the service pipe. Split insulation shall be held in place by stainless steel bands installed on not less than 18 inch centers. The insulation shall have passed the most recent boiling test and other requirements specified in the Federal Agency Guidelines. The insulation thickness for mineral wool shall in accordance with Part 11 as stated for fiberglass.
5) Outer Conduit: The steel conduit casing shall be airtight, pressure testable, smooth wall welded steel conduit. As noted above, with systems having 6 inches or smaller condensate lines, the trap return and pumped condensate service pipes shall share the same outer conduit. The steel conduit shall withstand H-20 loading with a minimum of 24 inches of cover.
6) Outer Conduit Insulation and Jacket: Conduit insulation shall be a minimum of 1 inch thick factory applied polyurethane foam, meeting ASTM C591. The outer jacket shall be either:

   a) Fiberglass (FRP) and filament wound directly onto the urethane foam insulation, with a minimum thickness of 0.160 inches for 6 inch and above service pipes and a minimum 0.120 inches for service pipes below 6 inches. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.
   b) High Density Polyethylene (HDPE) jacket with a minimum wall thickness of 0.175 inches. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.

7) Pipe Supports: All pipes within the inner casing shall be supported at not more than 10 foot intervals. These supports shall provide support at all sides of the piping and shall be designed to allow for continuous airflow and drainage of the conduit in place. The straight supports shall be designed to occupy not more than 10% of the annular air space. Supports shall be of the type where insulation thermally isolates the carrier pipe from the outer conduit. Supports which directly contact both the carrier pipe and the outer casing shall not be allowed. The surface of the insulation shall be protected at the support by a sleeve not less than 12 inches long, fitted with traverse and where required, rotational arresters.
8) Expansion Loops and Ells: Prefabricated expansion loops and ells can be utilized during the design and construction of the distribution to provide a layout/proper design in accordance with stress limits indicated by the code for pressure piping ASME B31.1. Loop and ell piping shall be installed in conduit suitable sized to allow for thermal expansion pipe movement. An analysis shall be performed by the Engineer to determine if it is more beneficial to use straight runs with

expansion joints in manholes versus using expansion loops and ells. Things to consider in the analysis include construction cost, phasing, and disturbance of grounds.

9) Field Joints: Insulate, seal, and protect all field joints in accordance with the manufacturer's written instructions and utilizing pipe manufacturer's procedures and field joint kits consisting of insulation, coatings and wrapping materials
10) Backfill: A 6 inch layer of sand or pea gravel shall be placed and tamped in the trench to provide uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. Bedding and backfill materials shall be as approved by the designer and manufacturer. Note that the composition of the backfill and the compaction of the backfill are extremely important due to possibility of settling and having the link seals and/or conduit system being crushed. This causes leaking into the casing and/or manholes and causes major damage. Designers must perform due diligence to verify existing soil conditions and provide a design that minimizes settling.
11) Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 6 inches minimum width, color; yellow, with warning and identification imprinted in big black letters continuously and repeatedly over entire tape length. Warning and identification shall read “CAUTION BURIED STEAM SYSTEM DISTRIBUTION PIPING BELOW” or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material

2. Penetrations

a. All penetrations through structure walls (building walls, tunnel walls, and manhole walls, etc.) shall be in accordance to the following requirements:

1) All penetrations shall be sealed by utilizing a water tight sleeve by “Link Seal” or approved equal. No dripping of water through the seal is permitted. Refer to Detail 3-1, Link Seals, Ends Seals, and Gland Seals.
2) The water tight sleeve shall be installed so it can be accessed from the inside of the structure.
3) The pipe alignment to the structure wall shall be as close to perpendicular as possible to provide enough space for the installation of the water tight sleeve.
4) The penetration hole shall either be made utilizing a smooth sleeve during the casting of the wall or made utilizing a core drill procedure so that the hole is smooth. (Core drilling is preferred because of the smoothness of the hole, the lack of a need for a sleeve which could be a cause for a leak point if it were to rust, and it removes the risk of accurately locating the sleeve during the construction of the manhole.) The size of the hole shall be coordinated with the water tight sleeve and the outside diameter of the conduit system.
5) All space between the back of the water tight sleeve and the exterior face of the structure shall be filled with waterproof foaming polyurethane insulation. In areas below the water table, the space between the back of the water tight sleeve and the exterior face of the structure shall be filled with waterproofing grout. The exterior structure waterproofing system (See Part 4.B, Waterproofing Materials and Part 4.C, Waterproofing Methods) shall overlap the foam insulation or grout sealing to

the outside of the piping system. If a membrane is used for waterproofing, the membrane shall overlap onto the penetrating pipe and be clamped with a stainless steel band clamp to the penetrating pipe.

3. Testing and Cleaning

a. Service Pipe

1) General: For most cases encountered for Yale's direct buried utilities, radiography and magnetic particle testing are not required per ASME B31.1. The requirements are specified to get the Contractor to use good welders. Leaks in piping in direct buried systems are difficult to find, can significantly hurt the construction schedule, and can cause other problems.
2) Examine 100% all factory butt welds (typically 2-1/2" NPS and greater) per radiography examination requirements in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via radiography examination – this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 20% of the estimated field welds. The Engineer shall specify that when there is a radiography examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.
3) Examine 100% of factory socket and fillet welds (typically 2" NPS and under) per magnetic particle method examination in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via magnetic particle examination – this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 20% of the estimated field welds. The Engineer shall specify that when there is a magnetic examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.
4) Cleaning shall be in accordance with Part 9, Pipe System Testing and Cleaning.

b. Steel Conduit casing shall be air tested at 8 psig. The test pressure shall be held for not less than one hour.

C. CHILLED WATER SYSTEMS

1. Materials

a. The complete underground direct buried chilled water distribution piping system shall include all required components such as carrier pipes, fittings, anchors, pipe supports, and insulation. The underground distribution piping systems shall not include valve manholes and the piping and equipment inside the manholes. The underground distribution piping systems shall include all piping and components to a point 12 inches inside the building, tunnel walls, or manhole walls. The underground piping distribution system shall be rated for 250 PSIG at fluid temperatures from 34 degrees Fahrenheit up to 140 degrees Fahrenheit. Each underground piping system shall be pre-engineered by the piping system manufacturer. All straight pipe sections, fittings, anchors, and other accessories shall be provided as required by the underground piping system manufacturer. The underground piping system shall be designed in accordance with the ASME B31.1. System shall be carbon steel pipe with fiberglass or HDPE jacketed. Acceptable products are POLYTHERM preinsulated piping system manufactured by PERMA-PIPE and CHILL-THERM preinsulated piping system manufactured by Thermacore Process, L.P.

b. The system supplier's representative shall be responsible for directing the installation and testing of the conduit system. It shall be certified in writing by the supplier that the representative is technically qualified and experienced in the installation of the system. The supplier's representative shall be present during the following work phases:

   1) Inspection and unloading
   2) Inspection of trench prior to laying of conduit
   3) Inspection of expansion loops
   4) Inspection of joining of system components
   5) Hydrostatic Testing (piping)
   6) Repair of any patchwork
   7) Back filling of conduit sections

c. The contractor shall not perform any of the above stated work in the absence of the system supplier's representative.

d. The contractor performing the work shall be responsible for the installation of the piping system and all other components of the underground conduit system, including the manholes and the piping equipment in the manholes. This responsibility shall include all site work and purchase of the piping system from the system supplier.

e. General Direct Buried Chilled Water System Specifications

   1) Service Pipe and Fittings Specifications: Refer to the Part 7 for all System Specifications.
   2) Protective Jacket: Conduit surfaces, inside and outside, shall be cleaned and made free of all loose debris. Protective jacket shall be:

      a) Fiberglass (FRP) and filament wound directly onto the urethane foam insulation. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.
      b) High Density Polyethylene (HDPE) jacket with a minimum wall thickness of 0.150 inches. Field enclosures shall be shrink wrap type per the manufacturer's recommendation.

   3) Expansion Loops and Ells: Expansion loops and ells are the preferred method in all installations. The design shall be of proper design in accordance with stress limits indicated by the code for pressure piping ASME B31.1.
   4) End Seals: Terminal ends of conduits inside building, tunnels, or manholes shall be equipped with factory furnished end seals. Terminate all conduits 12" beyond the inside face of manhole or building walls to protect any exposed piping insulation from damp-wall condensation.
   5) All fittings shall be factory prefabricated, insulated and jacketed

6) Insulation: Polyurethane Foam insulation, meeting ASTM C591 with the following insulation thickness:

Nominal Pipe Size (IN)	Insulation Thickness
1”	1”
1-1/2” to 3”	1-1/2”
4” to 6”	2”
8” to 14”	2-1/2”
16” to 20”	3”
22” and up	3-1/2”

7) A written certification from the underground distribution piping system manufacturer verifying that the conduit system contains no voids in the insulation prior to shipment to the job site shall be required. All insulation shall be factory tested for voids prior to application of the protective jacket by infrared inspection over the entire length or x-ray over the entire length.
8) Anchors: Anchors shall be designed by the manufacturer and factory prefabricated to prevent the ingress of moisture into the system.
9) Field Joints: Insulate, seal and protect all field joints in accordance with the manufacturer's written instructions and utilizing pipe manufacturer's procedures and field joint kits consisting of insulation, coatings and wrapping materials.
10) Backfill: A 6 inch layer of sand or pea gravel shall be placed and tamped in the trench to provide uniform bedding for the conduit. The entire trench shall be evenly backfilled with a similar material as the bedding in 6 inch compacted layers to a minimum height of 6 inches above the top of the insulated piping system. Bedding and backfill materials shall be as approved by the designer and manufacturer. Note that the composition of the backfill and the compaction of the backfill are extremely important due to possibility of settling and having the link seals and/or conduit system being crushed. This causes leaking into the casing and/or manholes and causes major damage. Designers must perform due diligence to verify existing soil conditions and provide a design that minimizes settling.
11) Buried Utility Warning and Identification Tape: Provide detectable aluminum foil plastic backed tape or detectable magnetic plastic tape manufactured specifically for warning and identification of buried piping. Tape shall be detectable by an electronic detection instrument. Provide tape in rolls, 6 inches minimum width, color; yellow, with warning and identification imprinted in big black letters continuously and repeatedly over entire tape length. Warning and identification shall read “CAUTION BURIED CHILLED WATER DISTRIBUTION PIPING BELOW” or similar wording. Use permanent code and letter coloring unaffected by moisture and other substances contained in trench backfill material.

2. Penetrations

Refer to Part 3.B.2, Penetrations.

3. Testing and Cleaning

a. Service Pipe

1) Examine 100% all factory butt welds (typically 2-1/2” NPS and greater) per radiography examination requirements in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via radiography examination – this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer

shall estimate the number of field welds and shall require testing of at least 10% of the estimated field welds. The Engineer shall specify that when there is a radiography examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.

2) Examine of 100% of factory socket and fillet welds (typically 2” NPS and under) per magnetic particle method examination in accordance with Part 9, Pipe System Testing and Cleaning. The Engineer shall specify a number of field welds to be tested via magnetic particle examination – this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of field welds and shall require testing of at least 10% of the estimated field welds. The Engineer shall specify that when there is a magnetic examination that does not pass, the repair weld of the failed weld shall be tested and an additional weld (located by the Engineer) shall be tested at no cost to Yale. If a welder has three failed welds, he must be removed from the project.

3) Cleaning shall be in accordance with Part 9, Pipe System Testing and Cleaning.

D. CONDUIT SYSTEM

1. Materials

a. All underground direct buried conduits shall be rigid galvanized steel and UL listed for use in wet locations. The conduit exterior and interior shall be hot-dipped galvanized in accordance with ANSI C80.1. The conduit threads shall be hot-dipped galvanized after fabrication. The conduit shall be provided with a corrosion protective coating. Conduit shall be NRTL-listed and labeled under UL 6. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube Company, or Western Tube & Conduit Corporation.

b. All conduit elbows, couplings, and fittings shall be rigid galvanized steel and UL listed for use in wet locations. Elbows, couplings, and fittings shall be hot-dipped galvanized and also have a corrosion protective coating. All conduit accessories shall be NRTL and UL listed.

c. Direct buried conduit shall be installed to meet the minimum cover requirements stated in NEC Table 300.5.

d. The contractor performing the work shall be responsible for the installation of the conduit system. This responsibility shall include the purchase of the conduit and accessories.

2. Penetrations

a. Refer to Part 3.B.2, Penetrations.

4. MANHOLES

A. GENERAL

1. General Layout Requirements

There are two types of manhole configurations that are accepted. The preferred configuration is to have forced ventilation with separate utility and support manholes that keep all electrical equipment out of the utility manhole with the hot piping. Requirements for this type of manhole layout are illustrated in Detail 4-1, Typical Steam Manhole Layout with Forced Ventilation. The more traditional configuration is to have natural ventilation with one manhole that includes all electrical equipment. Prior to beginning design for the project, refer to Yale Utilities for direction.

a. Operators must enter manholes periodically for maintenance and for isolating and starting systems. When entering the manholes, personnel must test for oxygen, possibly provide outside ventilation, and possibly wear harnesses from tripods. The configuration of piping within the manholes shall be made in consideration of an Operator maneuvering around the space with a harness connected to his or her body. Piping shall be routed along the walls as much as possible. Keep the middle area open. Arrange piping so the Operator does not have to crawl over and under things.

b. When a steam main is heated up after a shutdown or outage, the steam line can be relatively much colder than the steam entering the pipe. When the pipe is re-energized, this causes a significant amount of condensate to form in the distribution piping. Since there is no pressure in the steam main to drive the condensate out through the steam traps and into the condensate return piping, Operators must manually open drain valves in the manholes and let the condensate spill on the floor. Locate the drain valves so they are accessible and direct the drain away from the Operator. Note that the Operators cannot close these drain valves until the pressure in the system reaches 50 to 100 PSIG to a point where Operators know that the steam traps can push the condensate back through the piped return system. This underlines the need for ventilation in the manholes and sump pumps that are rated for temperature.

c. Consult with Yale Utilities before naming a new manhole or identifying existing manholes. Do not name new manholes MH-1 or 101.

2. Forbidden Utilities

a. Utilities that are not allowed in manholes under any circumstance include: natural gas, electric greater than 480VAC, telecom, domestic water, and storm sewer.

3. Minimum Size

The minimum size of the utility manhole shall be 8 feet wide by 8 feet long by 6 ½ feet tall (inside dimensions), which must provide adequate space for maintenance accessing piping system, including expansion joints, traps, valves, etc. Only Yale Utilities can permit a smaller manhole size. Provide a separate support manhole for sump pumps, lights, and fan. Minimum size for the support manhole shall be 4 feet wide by 4 feet long by 6 ½ feet tall (inside dimensions).

4. Ventilation System

Forced ventilation shall be used for all locations except as permitted by Yale Utilities. Requirements for natural ventilation are also included below for locations where natural ventilation is accepted by Yale Utilities. The air temperature in an unventilated manhole containing steam can be very difficult for an Operator to do work for any significant amount of time. Also, ventilation helps keep the humidity down. With the reduction of heat and humidity, ventilation helps to protect electrical equipment.

a. Forced Ventilation

Forced ventilation shall be provided via a fan located in the wall between the support manhole and the utility manhole. Air shall be drawn into the utility manhole through a ventilation pipe from the ceiling. The hot air shall discharge from the top of the utility manhole through a ventilation pipe. The fan shall be rated for 150 deg F, ambient service. The fan shall run continuously – no temperature control shall be provided. The fan shall be direct drive, 1750 RPM, propeller type, with a guard on the motor side and a backdraft damper on the outlet. The fan shall have aluminum housing and blades. Due to the radiated heat from the steam piping, it is difficult to select fan performance based off of trying to maintain a space temperature. At a minimum, size the fan for the greater of 15 air changes per hour or 500 CFM. The static pressure must be adequate to move the air and it is recommended to be a minimum of 0.5 inches H20. The motor shall be 115VAC, 1-phase, 60 hertz with 15-foot, 3-conductor SOOW type cord with bare lead ends. A single-phase motor starter in a NEMA 250, Type 12 enclosure shall be supplied with the fan assembly and shall be mounted next to the sump pump control panel. Refer to Part 4.A.8 for sump pump control panel location requirements. Label motor starter per Part 4.A.14.

b. Natural Ventilation

Only provide natural ventilation where approved by Yale Utilities. Each manhole shall be designed with a High vent and Low vent. The High vent shall be positioned at the furthest possible location from the Low vent across the manhole and one foot from the ceiling of the manhole. The Low vent shall be positioned one foot from the bottom of the manhole.

1) The High and Low vent pipes shall be routed to a common point. The maximum length of either vent pipe shall be 30 feet. The common point shall be positioned to be out of traffic (pedestrian and vehicular) travel ways and in the most conspicuous area located near the manhole.
2) Each vent pipes shall terminate with a “goose neck”, 36 inches above grade. The High and Low “goose necks” shall be 180 degrees from each other. The exposed portion of the vent pipes shall be painted with a rust inhibitive paint whose color shall be black or a more appropriate color to architecturally blend with the surroundings. In sensitive architectural areas, the vent pipes can be terminated below grade, within a vent coffer, similar to Detail 4-3, Vent Coffer Details.

c. Ventilation Piping

Whether for forced or natural ventilation, the vent piping shall be as follows:

1) Vent pipes for forced ventilation shall be sized by the Engineer to keep air velocity to acceptable levels and in consideration of static pressure. Vent pipes for forced and natural ventilation shall be a minimum of 8” nominal pipe size. Larger pipe sizes may be required for forced ventilation and natural ventilation of larger manholes.
2) Vent Pipe Material: Shall be:
    a) Cast iron pipes. Refer to Part 3.B.2, Penetrations for sealing the vent piping penetrations; or,
    b) Schedule 40 steel pipes. The steel pipes shall be cast within the manhole walls with a water stop. All steel shall be painted, refer to Part 12, Painting.
3) The High and Low vent pipes shall be routed to a common point. The maximum length of either vent pipe shall be 30 feet. The common point shall be positioned to

be out of traffic (pedestrian and vehicular) travel ways and in the most conspicuous area located near the manhole.

4) Each vent pipes shall terminate with a “goose neck”, 42 inches above grade. The High and Low “goose necks” shall be 180 degrees from each other. The exposed portion of the vent pipes shall be painted black, or a more appropriate color to architecturally blend with surroundings as approved by Yale Utilities. In sensitive architectural areas, the vent pipes can be terminated below grade, within a vent coffer, similar to Detail 4-3, Vent Coffer Details. No mushroom style caps shall be used – experience has shown that snow drift blocks air flow.

5. Minimum Cover

a. The minimum cover on top of manholes shall be in accordance to the following areas:

1) Paved areas (parking lots, driveways, roadways, sidewalks, etc.): 18 inches.
2) Landscape areas (lawn/grassed areas, planting beds, etc.): 3 feet

6. Manhole Lids/ Access Doors

Provide for utility and support manholes.

a. Vehicle Traffic Areas:

1) Opening: Each shall meet HS-20 traffic loading requirements.

a) Grade Rings: Provide 2 or 3 reinforced concrete rings, of 6-8 inch total thickness and match 42 inch diameter frame and cover.
b) Gaskets: ASTM C 443, rubber.
c) Joints inside and outside shall be patched with non-shrink grout.

2) Manhole Frames and Covers: ASTM A 536, Grade 60-40-18, heavy-duty, traffic bearing, ductile iron, 42 inch opening by 7 to 9 inch riser with 4 inch minimum width flange, and 44 inch minimum diameter cover, indented top design, with lettering "STEAM" or “CHW” cast into cover.
3) Manhole Security/Lock:

a) Provide “LockDown” manhole security system by LockDown-LockDry, a Division of BartonSouthern (800-572-3110) for each manhole opening.
b) Provide one “Abloy” PL330/25 padlock or “Best” 41B722 padlock and keys for each “LockDown” system.

b. Non Vehicle Traffic Areas:

1) General: Furnish each access door assembly manufactured as an integral unit, complete with all parts, and ready for installation, meeting HS-20 traffic loading requirements.
2) Aluminum Access Doors and Frames: Fabricate units of aluminum.

a) 6 mm aluminum diamond plate with stiffeners for doors.
b) 6 mm aluminum channel with perimeter anchor flange for frame.
c) Doors shall be insulated with polystyrene insulation and provided with stainless steel hinges and chrome plated hardware.
d) Provide Bilco Type “J”, Babcock-Davis “B-FHA” Series, or acceptable.

3) The frame drain shall be routed to the sump at the bottom of the manhole.
4) Doors shall be spring loaded to open.
5) Provide two keys for each door.

7. Ladders
    a. Comply with ANSI A14.3.
    b. Siderails: Continuous, 1/2 by 2-1/2 inch steel flat bars, with eased edges, spaced 18 inches apart.
    c. Bar Rungs: 3/4 inch diameter steel bars, spaced 12 inches o.c.
    d. Fit rungs in centerline of side rails; plug-weld and grind smooth on outer rail faces.
    e. Support each ladder at top and bottom and not more than 60 inches o.c. with welded or bolted steel brackets. Size brackets and fasteners to support design loads specified in ANSI A14.3. Refer to Detail 4-4.
    f. Provide non-slip surfaces on top of each rung, either by coating rung with aluminum-oxide granules set in epoxy-resin adhesive or by using a type of manufactured rung filled with aluminum-oxide grout.
    g. Galvanize ladders, including brackets and fasteners, to G-90 at all locations.
    h. Provide extension egress sections (ladder extension safety post) to all ladders similar to “Bilco Ladder-Up” or approved equal.
8. Sump Pumps
    a. The prevention of the flooding of a manhole is critical to life safety and energy savings. A flooded manhole can cause condensate induced water hammer in the steam piping system and cause catastrophic failure. Flooded manholes destroy insulation and severely decrease the life of the system. In addition, flooded manholes are very difficult to service because they have to be pumped out from above and they are usually very hot because the insulation is usually gone. For these reasons, sump pumps cannot be “value engineered” out of the design of a utility manhole that contains steam or condensate piping.
    b. Sump pumps shall be located in the support manhole so that the electronics are located in the cooler space, outside of the utility manhole. A trench shall be provided to the sump from the utility manhole to the support manhole.
    c. Provide duplex electric powered sump pumps which shall be alternate lead/lag. When one pump is not doing the duty, the other pump shall energize to help handle the load. Single pump systems are not allowed. No steam powered sump pumps are allowed.
    d. Sump pump capacity shall be a minimum of 25 GPM for manholes with no chilled water piping or with chilled water piping under 8” NPS. Sump pumps in manholes that have chilled water piping of 10” NPS or greater shall be sized for 50 GPM.
    e. Due to ease of construction, the preference for the basin is to have a 3’ diameter by 3’ deep stainless steel cylinder. Basins of concrete or cast iron can also have minimum dimensions of 3’ x 3’ x 3’. The sump shall have a 1/2” grid stainless steel mesh over the top to prevent large debris from entering the sump and to allow maintenance crew to clear the debris from the up top, not down in the sump. Do not provide an integral strainer with the pump so that it does not clog. Do not provide enclosed basins – there are no floor drains in the manholes. Water shall make its way on the floor to the sump.
    f. General Pump Specifications
        1) Pumps shall be vertical, centrifugal, end suction, single stage, complete with float

switch controls. The pump shall be rated to handle liquids up to 200 degrees F for manholes that have steam or condensate. For manholes that have chilled water only, the sump pumps can be rated for liquids up to 100 degrees F. The pump shall have 1/2 inch solids handling capability.

2) Casing: Cast iron with integral cast-iron inlet strainer and Ryton legs to elevate the pump to permit flow into the impeller. Discharge female threaded connection shall be arranged for vertical discharge and suitable for plain-end pipe connection. Casing shall have epoxy coating for corrosion resistance. Provide stainless steel lifting ring, screws, and bolts.
3) Impeller: Statically and dynamically balanced, open or semiopen, overhung, single suction, vortex style, fabricated from Nylon, keyed to shaft and secured by a locking capscrew. Volute to be epoxy-coated cast iron.
4) Seals: Mechanical seals.
5) Submersible Motor: 460VAC, 3 phase, 60 hertz oil filled for rapid heat dissipation with 15-foot, 3-conductor SOOW type cord with bare lead ends.
6) Acceptable Manufacturers: Crane Barnes, Goulds, Little Giant, or Zoeller

g. Sump pump discharge piping shall be configured to allow for easy dismantling of pump for removal and replacement.

h. Install a non-slam check valve and gate valve on the discharge side of pump.

i. Duplex Sump Pump Control Panel: The pump manufacturer shall provide a factory-assembled, and UL listed and labeled duplex sump pump control panel for each pair of sump pumps. For the preferred configuration where there is a utility manhole and a support manhole, the duplex sump pump control panel shall be located in the building supplying power for the sump pump circuit. For the traditional manhole configuration where there is only a utility manhole, the control panel shall be included in the manhole. Refer to Yale Utilities for sump pump control panel power supply location. The control panel shall be supplied with the following components:

1) NEMA 4X stainless steel enclosure with ANSI 61 light grey exterior and white interior. The enclosure shall have external mounting tabs for wall mounting.
2) Three-pole molded case thermal magnetic circuit breaker sized for motor load, with external flange mounted disconnect switch handle. External disconnect switch handle shall be capable of being padlocked in the open position.
3) NEMA rated motor starters with three-pole motor circuit protectors to provide individual motor starter short circuit protection, three-pole magnetic contactors, and Class 10 ambient compensated bimetal overload relays.
4) Control power transformer with primary and secondary fuses, line voltage primary and 120V grounded secondary, with a minimum of 50VA additional capacity.
5) Door-mounted HAND-OFF-AUTO selector switch, START pushbutton, STOP pushbutton, RESET pushbuttons for overload relays, red LED MOTOR STOPPED, and green LED MOTOR RUNNING pilot lights for each pump motor.
6) Solid state lead-lag pump alternator with float status lights.
7) Lag pump delay start relay.
8) Alternator shall be suitable for four sump float operation (low level – pumps off, lead pump on, lag pump on, high level alarm). Dry contact shall be provided for remote high level alarm notification.
9) Alternator selector switch to override the lead-lag alternator and allow operation of pump 1 or pump 2 only.
10) 115V anti-condensation heater connected to 120V control transformer. Heater shall

be provided with adjustable thermostat and over-temperature control.

11) Local external high level alarm light and horn.
12) 115VAC service light to provide internal panel illumination during service work.
13) Internal 115VAC duplex convenience receptacle.
14) Terminal blocks shall be provided for connection of level controls and other control wiring as required for proper pump installation.
15) Motor starters, relays, and other internally mounted components shall be DIN rail mounted.
16) Internal wiring shall be THHN/THWN/MTW 600V insulated copper wire.
17) Wire between devices shall be neatly routed inside plastic wireways with slots for wiring and snap-on plastic covers.
18) Field wiring shall be terminated at insulated terminal strips with compression plates. No more than two wires shall be installed at each terminal.
19) Sump float switches shall be mounted from top to bottom in the following order:
    a) High Level Alarm
    b) Lag Pump On
    c) Lead Pump On
    d) Low Level
20) Pump sequence of operation shall be as follows:
    a) Sump empty: Pumps off.
    b) Sump level rises to lead pump float switch: Start lead pump.
    c) Sump level rises to lag pump float switch: Start lag pump.
    d) Sump level rises to high level alarm float switch: Transmit high level alarm to Yale Customer Service Control Center. Refer to Yale Utilities for location of alarm termination location.
    e) Shut off pumps when level falls below low level float switch.
    f) Pumps alternate lead and lag for next pump out cycle.

9. Lighting

a. Provide 2-lamp, 32-watt, 4-foot fluorescent fixture with electronic T8 ballast, universal voltage (120-277VAC), polycarbonate lens, stainless steel latches, and non-metallic housing. Manufactures shall be Simkar (Catalog No. OV451232-B11SSUNV) or approved equal.

b. Light fixtures shall be mounted as close to the manhole ceiling as possible.

c. For manhole throats that are deeper than 10 feet, mount light fixture vertically in throat to provide lighting for ladder access. Light fixture shall not impede personnel access into the manhole.

d. Manhole maintained light level shall be 10 footcandles minimum.

e. Provide 20A, 120/277VAC, Marine Grade, single-pole toggle switch with lighted handle. Handle shall illuminate when the switch is on. Manufacturer shall be Hubbell (Catalog No. HBL1221PL). Alternate manufacturers are not allowed.

f. Provide silicone rubber weatherproof switch plate for use with above light switch. Manufacturer shall be Hubbell (Catalog No. HBL1795). Alternate manufacturers are not allowed.

g. Light switch shall be mounted as close to the manhole throat opening as possible.

10. Receptacles
    a. Provide 20A, 125VAC, Marine Grade, duplex ground fault circuit interrupter (GFCI) receptacle. Manufacturer shall be Hubbell. Alternate manufacturers are not allowed.
    b. Provide Marine Grade weatherproof cover plate for use with above receptacle. Manufacturer shall be Hubbell. Alternate manufacturers are not allowed.
    c. Receptacle shall be mounted as closed to the manhole throat opening as possible.
    d. Receptacles in manhole shall be mounted 4 feet above finished floor. One receptacle per chamber of manhole is required.
11. Wire and Cable – Steam and Condensate Manholes
    a. All power and control conductors shall be UL listed, Type SF-2, stranded copper, 600 Volt Appliance and Fixture Wire. Manufacturers shall be Allied Wire & Cable, Cable USA, First Capitol Wire & Cable, York Wire & Cable, Inc. or approved equal. Aluminum conductors are not allowed.
12. Wire and Cable – Chilled Water Manholes
    a. All power and control conductors shall be UL listed, Type XHHW, 600V, stranded copper cable. Manufacturers shall be Southwire Company, American Insulate Wire Corp., General Cable, or approved equal. Aluminum conductors are not allowed.
13. Conduit and Accessories
    a. Exposed conduit shall be rigid galvanized steel. The conduit exterior and interior shall be hot-dipped galvanized in accordance with ANSI C80.1. The conduit threads shall be hot-dipped galvanized after fabrication. The conduit shall be provided with a corrosion protective coating. Conduit shall be NRTL-listed and labeled under UL 6. Manufacturers shall be Allied Tube and Conduit, Wheatland Tube Company, or Western Tube & Conduit Corporation.
    b. Conduit elbows, couplings, and fittings shall be rigid galvanized steel. Elbows, couplings, and fittings shall be hot-dipped galvanized and also have a corrosion protective coating. All conduit accessories shall be NRTL and UL listed.
    c. Sheet metal pull boxes and junction boxes shall be NEMA 250, Type 4X fiberglass or stainless steel. All boxes shall be UL listed.
    d. Cast metal outlet and device boxes shall be galvanized and epoxy- or polyester-coated malleable iron, Type FD or FS, with gasketed cover. All boxes shall be UL listed.
    e. Conduit bodies shall be galvanized cast steel or malleable iron Form 8 with oil-resistant gasket and galvanized cast steel or malleable iron cover. Provide mogul bodies for fittings in trade sizes 2 inch and larger. Conduit bodies shall be UL listed.
    f. Exposed conduit at connections to transformers, motor-driven equipment, vibrating equipment, and equipment requiring position adjustment shall be liquidtight flexible metal conduit (LFMC). The conduit shall be of the flexible steel type GP with PVC jacket and used in accordance with NEC Article “Liquidtight Flexible Metal Conduit: Type LFMC.” The conduit shall be NRTL-listed and labeled under UL 360. UL listed steel insulated-throat screw-in connectors, suitable for use as a grounding fitting, shall be used where LFMC conduit is used.

14. Identification

   a. Equipment Identification

      1) Label shall be engraved, laminated acrylic punched or drilled for screw mounting with white letters on a black background. Minimum letter height shall be 3/8 inch.
      2) Fasteners shall be self-tapping, stainless-steel screws.
      3) Mount to front panel of equipment.
      4) Legend shall be as follows:

         a) Equipment designation (i.e. Sump Pump No. 1 Control Panel)
         b) Power source equipment designation and circuit breaker number (if fed from a panelboard) (i.e. Panelboard DP-1 Ckt. 21, 23, 25)
         c) Power source location – Building, Room and/or Floor (i.e. Central Power Plant, 2nd Floor Electrical Room)

   b. Receptacle and Light Switch Identification

      1) Label shall be engraved, laminated acrylic punched or drilled for screw mounting with white letters on a black background. Minimum letter height shall be 3/8 inch.
      2) Fasteners shall be self-tapping stainless-steel screws.
      3) Mount label on wall next to receptacle or switch.
      4) Legend shall be as follows:

         a) Power source equipment designation and circuit breaker number (i.e. Panelboard DP-4 Ckt. 15)
         b) Power source location – Building, Room and/or Floor (i.e. Central Power Plant, 3rd Floor Mechanical Room)

   c. Raceway Identification

      1) Label shall be colored, heavy duty, waterproof, fade resistant self-adhesive vinyl.
      2) System color identification for low voltage systems equipment shall be as follows:

         a) Power Circuits: Black letters, indicating system or service and voltage, on an orange field.
         b) Control Wiring: Green and red.

      3) Apply colored tape around conduit as follows:

         a) At least once in each 20 feet of conduit.
         b) Where conduit enters inaccessible spaces.
         c) At least once in each room or area through which the conduit passes.

15. Structural Requirements

   a. Reinforcing Bars: ASTM A 615 Grade 60 (ASTM A 615M Grade 400), deformed.

   b. Supports for Reinforcement: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars and welded wire fabric in place. Use wire bar-type supports complying with CRSI specifications

   c. Prepare design mixes for each type and strength of concrete by either laboratory trial batch or field experience methods as specified in ACI 301. For the trial batch method, use an independent testing agency acceptable to The Designer for preparing and reporting proposed mix designs.

d. Design mixes to provide normal weight concrete with the following properties as indicated on drawings and schedules:

1) 4000 psi (27.6 MPa), 28-day compressive strength; water-cement ratio, 0.45 maximum (non-air-entrained).

B. WATERPROOFING MATERIALS

Provide one of the following options or a combination of two of the options:

1. Option 1

Provide a dual-waterproofing, resealable, composite sheet membrane system composed of high-density polyethylene with a sodium-bentonite face designed for buried concrete or masonry construction, as manufactured by Tremco, equal system.

a. Obtain primary waterproofing materials of each type required from a single manufacturer to greatest extent possible. Provide accessory materials that are approved by membrane manufacturer.

b. Membrane Properties: Equal to Tremco “Paraseal Membrane LG“, or equal for use on buried vertical and horizontal conditions such as backfilled foundation walls, below slab with bentonite-side up, retaining walls and ponds:

1) Puncture resistance: 95 psi.
2) Tensile strength: 4,000 psi.
3) Water permeability through membrane: 2.7 x 10-13 cm3/cm2/sec.
4) Water permeability through seam: 4.6 x 10-13 cm3/cm2/sec.
5) Resistance to hydrostatic head: 150 feet-zero leakage
6) Percent elongation: 700 percent
7) Water migration under membrane: 0 at 150 ft. water head
8) Warranted crack-bridging capability: developing cracks to 1/8 inch
9) Sheet size: 24'-0" x 4'-0"

c. Auxiliary Materials

1) Adhesives and Joint Tape: Provide types of adhesive compound and tapes recommended by waterproofing sheet manufacturer for bonding to substrate (if required), for waterproof sealing of seams in membrane, and for waterproof sealing of joints between membrane and flashings, adjoining surfaces, and projections through membrane.
2) Primers: Provide type of concrete primer recommended by manufacturer of sheet waterproofing material for applications required.
3) Flashing Materials: Except as otherwise indicated, provide types of flexible sheet material for flashing as recommended by waterproofing sheet manufacturer.
4) Protection Board: Provide type of protection board recommended by waterproofing sheet manufacturer. Include adhesives recommended by manufacturer.

2. Option 2

Provide a Pre-applied Integrally Bonded Sheet Waterproofing Membrane: A 1.2 mm nominal thickness composite sheet membrane comprising 0.8 mm (0.030 in.) of high density polyethylene film, and layers of specially formulated synthetic adhesive layers. The membrane shall form an integral and permanent bond to poured concrete to prevent water migration at the interface of the membrane and structural concrete. Provide membrane with the following physical properties:

Property	Test Method	Typical Value
Color		White
Thickness	ASTM D 3767 Method A	1.2 mm (0.046 in.) nominal
Low Temperature Flexibility	ASTM D 1970	Unaffected at -23°C (-10°F)
Elongation	ASTM D 412 Modified1	>300%
Crack Cycling at -23°C (-10°F), 100 Cycles	ASTM C 836	Unaffected
Tensile Strength, Film	ASTM D 412	27.6 MPa (4,000 lbs/in.2) minimum
Peel Adhesion to Concrete	ASTM D 903 Modified2	880 N/m (5.0 lbs/in.)
Lap Adhesion	ASTM D 1876 Modified3	440 N/m (2.5 lbs/in.)
Resistance to Hydrostatic Head	ASTM D 5385 Modified4	>70 m (231 ft)
Puncture Resistance	ASTM E 154	990 N (180 lbs) minimum
Permeance	ASTM E 96 Method B	<0.6 ng/m2sPa (0.01 perms)
Water Absorption	ASTM D 570	<0.5%

a. Footnotes:

1) Elongation of membrane is run at a rate of 50 mm (2 in.) per minute.
2) Concrete is cast against the protective coating surface of the membrane and allowed to cure (7 days minimum). Peel adhesion of membrane to concrete is measured at a rate of 50 mm (2 in.) per minute at room temperature.
3) The test is conducted 15 minutes after the lap is formed as per manufacturer's instructions and run at a rate of 50 mm (2 in.) per minute at -4°C (25°F).
4) Hydrostatic head tests are performed by casting concrete against the membrane with a lap. Before the concrete sets a 3 mm (0.125 in.) spacer is inserted perpendicular to the membrane to create a gap. The cured block is placed in a chamber where water is introduced to the membrane surface up to a head of 70 m (231 ft) of water, which is the limit of the apparatus.

Properties	Test	Requirement
Tensile Strength	ASTM D412	1200 psi
Ultimate Elongation	ASTM D412	410%

5) Elastomeric nosing: Cold-applied 2-part polyurethane resin mixed with sand particle aggregate. Material shall flow so as to fill voids in concrete blockout and underneath perforated flanges of sealing insert creating watertight bond with sealing insert.

Properties	Test	Requirement
Tensile Strength	ASTM D 2240	600 psi
Ultimate Elongation	ASTM D 2240	25%

b. Provide a Fluid Applied Waterproofing Membranes: A two part, self-curing, synthetic rubber based material. Fluid applied membranes shall meet or exceed the performance requirements of ASTM C 836 and other ASTM standards as shown in the following table.

1) Waterproofing Membrane Physical Properties

Property	Test Method	Typical Value
Color		terra cotta
Cured Film Thickness	ASTM D 3767 Method A 1.5 mm (0.060 in.) nominal	1.5 mm (0.060 in.) nominal
Solids Content	ASTM D 1644 100%	100%
Flexibility, 180° bend over 25 mm (1 in.) mandrel at 32°C (-25°F)	ASTM D 1970	Unaffected
Elongation	ASTM D 412	500% minimum
Peel Adhesion to Concrete	ASTM D 903 Modified	880 N/m (5 lbs/in.)

2) Protection Board

a) Asphalt Hardboard: A premolded semi-rigid protection board consisting of bitumen, mineral core and reinforcement. Provide 3 mm (0.125 in.) thick hardboard over waterproofing on horizontal surfaces.
b) Expanded Polystyrene Protection Board: 25 mm (1 in.) thick for vertical applications with the following characteristics.
c) Normal Density: 16 kg/m3 (1.0 lb/ft3)
d) Thermal Conductivity, K factor: 0.24 at 5°C (40°F), 0.26 at 24°C (75°F)
e) Thermal Resistance, R-Value: 4 per 25 mm (1 in.) of thickness.

C. WATERPROOFING METHODS

1. General

Install waterproofing per manufacturer recommendation. Both membrane options can be used during blind side concrete pours. Option 1 and the Fluid Applied Waterproofing portion of Option 2 can be used with access to concrete pour and stripping of forms or for precast units.

2. Membrane Insallation

a. Membrane Installation, Vertical Applications

1) Substrates shall be smooth and sound.
2) Strictly comply with installation instructions in manufacturer's published literature, including but not limited to, the following:

a) Apply membrane with the HDPE film facing the prepared soil retention system (wood lagging, sheet piling, gunite, shotcrete, etc.). Remove the release liner and fasten membrane along uncoated edge to plywood with large head nails or staples.
b) Apply succeeding sheets by overlapping the previous sheet 75 mm (3 in.) along the uncoated edge of the membrane. Side laps must be firmly rolled to ensure a tight seal.
c) Overlap the ends of the membrane 75 mm (3 in.). Apply manufactured provided tape centered over the end lap and roll firmly to ensure a tight seal. Remove release liner for Option 2.

3) The Sub-Contractor has the option of using fluid-applied waterproofing, in lieu of pre-applied membrane waterproofing on vertical surfaces. For vertical blindside surfaces, ie., against lagging, the contractor must use pre-applied integrally bonded

waterproofing.

b. Membrane Installation, Horizontal Applications

1) Earth and stone substrates shall be well compacted to produce an even, solid substrate. Remove loose aggregate or sharp protrusions. Concrete substrates shall be smooth or broom finished and monolithic. Fill gaps or voids greater than 13 mm (0.5 in.). Remove standing water prior to membrane applications. Membrane waterproofing shall be used for all horizontal blindside conditions, ie. underneath all slabs, mats and wall footings poured on-grade or on working slabs.
2) Strictly comply with installation instructions in manufacturer's published literature, including but not limited to, the following:

   a) Apply membrane with the HDPE film facing the prepared substrate. Remove the release liner during application when using Option 2. Sheet Membrane shall be used for all horizontal blindside conditions, i.e, underneath all slabs, mats and wall footings poured on-grade or on working slabs.
   b) Apply succeeding sheets by overlapping the previous sheet 75 mm (3 in.) along the uncoated edge of the membrane. Lap area must be firmly rolled to ensure a tight seal.
   c) Overlap the ends of the membrane a minimum of 75 mm (3 in.) and apply manufacturer provided tape centered over the lap and roll firmly to ensure a tight seal.

c. Protection

1) Protect membrane in accordance with manufacturer's recommendations until placement of concrete. Inspect for damage just prior to placement of concrete and make repairs in accordance with manufacturer's recommendations

d. Inspection and Repair

1) All waterproofing must be inspected and approved by waterproofing manufacturer's representative prior to pouring concrete. The representative shall submit a written report to the Designer and the Construction Manager describing the condition of all waterproofing. If the waterproofing is unacceptable, define what types of repairs need to be implemented for approval. A final approval report must be submitted by the representative to the Designer prior to pouring concrete

3. Fluid Applied Installation

a. The Sub-Contractor shall examine conditions of substrates and other conditions under which this work is to be performed and notify the Construction Manager, in writing, of circumstances detrimental to the proper completion of the work. Do not proceed with work until unsatisfactory conditions are corrected.

b. Preparation of Substrates

1) Refer to manufacturer's literature for requirements for preparation of substrates. Surfaces shall be structurally sound and free of voids, spalled areas, loose aggregate and sharp protrusions. Remove contaminants such as grease, oil and wax from exposed surfaces. Remove dust, dirt, loose stone and debris. Use repair materials and methods, which are acceptable to manufacturer of the fluid-applied waterproofing.
2) Cast-In-Place Concrete Substrates:

a) Waterproofing application may commence as soon as the substrate can accept foot traffic. Surface shall be free of any visible water.
b) Fill form tie rod holes with concrete and finish flush with surrounding surface.
c) Repair bugholes over 13 mm (0.5 in.) in length and 6 mm (0.25 in.) deep and finish flush with surrounding surface.
d) Remove scaling to sound, unaffected concrete and repair exposed area.
e) Grind irregular construction joints to suitable flush surface.

3) Masonry Substrates: Apply waterproofing over concrete block and brick with smooth trowel-cut mortar joints or parge coat.
4) Plywood Substrates: Pretreat all plywood joints with 75mm (3 in.) wide, reinforced self-adhesive tape. Secure all fasteners.
5) Related Materials: Treat joints and install flashing as recommended by waterproofing manufacturer.

c. Installation

1) Refer to manufacturer's literature for recommendations on installation, including but not limited to, the following:

a) Apply minimum 3.0 mm (0.120 in.) in all areas to be waterproofed.
b) If area to be waterproofed is in direct sunlight and temperature is rising, apply "scratch coat" (a thin application of fluid applied waterproofing) prior to the full application of the waterproofing membrane.
c) In applications where a minimum slope of 11 mm/m (0.13 in./ft) can not be achieved, a two coat application of membrane is recommended to achieve the total thickness.
d) Apply protection board and related materials in accordance with manufacturer's recommendations.

d. Cleaning and Protection

1) Remove any masking materials after installation. Clean any stains on materials, which would be exposed in the completed work.
2) Protect completed membrane waterproofing from subsequent construction activities as recommended by manufacturer.

e. Inspection and Repair

1) All waterproofing must be inspected and approved by waterproofing manufacturer's representative prior to pouring concrete. The representative shall submit a written report describing the condition of all waterproofing. If the waterproofing is unacceptable define what types of repairs need to be implemented for approval. A final approval report must be submitted by the representative to the Designer prior to pouring concrete.

5. TUNNELS

A. GENERAL

1. Forbidden Utilities

Utilities that are not allowed in tunnels under any circumstance include: natural gas, and electric greater than 480VAC. No pipes shall be routed through tunnels that will reduce access through the tunnel. No pipes shall be routed perpendicular through a tunnel that will require somebody to duck or walk over the pipe.

2. Minimum Size

   The minimal width of a tunnel shall be 3 feet of clear walk space plus the maximum width of the pipe racking system. The minimum clear height for the walking space aisle shall be 6 ½ feet.

3. Egress

   a. Egress/access points/shafts shall be placed at a maximum of 300 feet or less where required by code.

   b. Provide ladders. Provide landings as required by vertical length in accordance to OSHA requirements.

   c. Provide security and locks on doors per Yale Utilities. The position of doors shall be monitored electronically.

4. Ventilation System

   a. Ventilation shall be forced mechanical system with supply and exhaust fans.

   b. Ventilation fans shall run continuously, regardless of space temperature.

5. Minimum Cover

   a. The minimum cover on top of tunnels shall be in accordance to the following areas:

      1) Paved areas (parking lots, driveways, roadways, sidewalks, etc.): 18 inches
      2) Landscape areas (lawn/grassed areas, planting beds, etc.): 3 feet

6. Drains

   a. Drains: Floor drains shall not be included in tunnels. Provide a trench in the edge of the tunnel to allow water to collect and be directed to the sump.

7. Duplex Sump Pumps

   a. Refer to Section 4 Paragraph A.8 for sump pumps. Note: Duplex sump pumps only required at low elevations.

8. Simplex Sump Pump

   a. If water can overflow the sump and flow down to another lower elevation where there is a sump and no flooding or damage is caused by that water overflowing to the building, tunnel, etc., then a single pump will suffice in that higher elevation sump.

   b. Sump pump GFCI receptacle shall be located a minimum of 4 feet above finished floor.

   c. General Pump Specifications

      1) Refer to Section 4 Paragraph A.8.f.1) through 4) and 6).
      2) Submersible Motor: 115VAC, 1-phase, 60 Hz oil filled for rapid heat dissipation with 15-foot, 3-conductor SOOW type cord and plug.
      3) Control panel and remote overflow alarm not required for single pump applications.

9. Lighting

a. Refer to Part 4.A.9.a.

b. Light fixtures shall be mounted as close to the tunnel ceiling as possible.

c. Tunnel maintained light level shall be 10 footcandles minimum.

d. Provide 20A, 120/277VAC, Marine Grade, single-pole or three-way toggle switch with lighted handle. Handle shall illuminate when the switch is on. Manufacturer shall be Hubbell (Catalog No. HBL1221PL for single-pole and Catalog No. HBL1223PL for three-way). Alternate manufacturers are not allowed.

e. Provide silicone rubber weatherproof switch plate for use with above light switch. Manufacturer shall be Hubbell (Catalog No. HBL1795). Alternate manufacturers are not allowed.

f. Light switches shall be mounted near tunnel entry and exit points and intermediate locations as needed.

10. Emergency Lighting and Exit Signs

a. Provide Simkar emergency light fixture (Catalog No. SWLEM) or approved equal.

b. Location of emergency light fixtures to be per NFPA 101 Life Safety Code.

c. Provide Simkar exit sign (Catalog No. SWLED) or approved equal.

d. Location of exit signs to be per NFPA 101 Life Safety Code.

11. Receptacles

a. Refer to Part 4.A.10.a.

b. Refer to Part 4.A.10.b.

c. Receptacles in tunnel shall be mounted 4 feet above finished floor and approximate every 25 feet.

12. Wire and Cable – Steam and Condensate Tunnels

a. Refer to Part 4.A.11.

13. Wire and Cable – Chilled Water Tunnels

a. Refer to Part 4.A.12.

14. Conduit and Accessories

a. Refer to Part 4.A.13.

15. Identification

a. Refer to Part 4.A.14.

16. Structural Requirements

Refer to Paragraph 4.A.10, Structural Requirements for manholes.

B. WATERPROOFING MATERIALS

Refer to Paragraph 4.B, Waterproofing Materials for manholes.

C. WATERPROOFING METHODS

Refer to Paragraph 4.B, Waterproofing Methods for manholes.

6. UNDERGROUND UTILITY SYSTEM ROUTING

A. GENERAL

1. Survey

   As part of the design/development of the underground utility routing, the proposed routing shall have a subsurface utility survey performed on it, including the four level utility steps (Utility Quality Levels A – D) to determine the exact location of all existing utilities within the utility routing.

2. Minimum Distance Between Utilities

   The minimum distance between new utilities and existing utilities shall be one foot. If less than one foot of clearance is utilized, flowable fill shall be used for backfill between and around the utilities (minimum six inches between utilities).

3. Vertical Pipe Routed

   It is preferred that no low points be created in piping systems between manholes so that all piping can be completely drained. Also, it is preferred that no high points be created in the piping systems between manholes so that all piping can be completely vented so that a hydrostatic test can occur.

   a. The minimum depth of the direct buried steam system and chilled water system shall be designed with a minimum cover of four feet. This minimum cover requirement can be reduced with approval from Yale Utilities and the design engineer taking into the necessary requirements to add additional insulation to protect from freezing and/or additional design for structural protection to protect against vertical loading. Within landscape and planting, including grass areas, the minimum four (4) feet cover should be maintained.

B. DIRECT BURIED STEAM SYSTEM

1. Thermal Expansion

   The routing of the direct buried steam system shall take into consideration the thermal expansion of the system piping. An analysis shall be performed by the Engineer to determine if it is more beneficial to use straight runs with expansion joints in manholes versus using expansion loops and ells. Things to consider in the analysis include construction cost, phasing, and disturbance of grounds. If proper expansion cannot be compensated with expansion loops and ells, manholes with expansion joints can be utilized.

2. Pipe Slope

   The direct buried steam piping shall be pitched/sloped at a minimum of 0.5% in the direction of steam flow or minimum of 1.0%. Manholes shall be placed at low points to provide minimally an area for trapping the condensate.

3. Maximum Distance Between Manholes

   The maximum distance of the direct buried steam system between manholes with trap stations shall be 300 feet.

C. DIRECT BURIED CHILLED WATER SYSTEM

1. General

   a. All direct buried chilled water line sizes 12 inches in diameter and larger shall have high point air release valves within manholes.

D. DIRECT BURIED CONDUIT

1. General

a. All direct buried conduits shall have a minimum of 12 inches of separation between steam, condensate, and chilled water system direct buried piping.

E. TUNNEL

1. General

a. Tunnels containing steam system piping shall be sloped as indicated above.

7. PIPING SYSTEMS

A. PIPING CODE COMPLIANCE

All piping systems (steam, condensate return, and chilled water) in all locations within the utility distribution system scope shall be designed, fabricated, erected, and tested in accordance with ASME B31.1. Building systems may be in accordance with ASME B31.9 as that code allows.

B. DESIGN PARAMETERS

1. General

a. All piping systems and all components within the piping systems shall be designed for the "Maximum Design Pressure and Temperature" conditions listed below. These conditions are the maximum pressure and temperature that will be experienced in the piping system (exclusive of any type of water hammer). This includes thermal stress analyses and anchors for expansion joints where a pressure thrust force can be experienced. This is the "Design Pressure" per ASME B31.1. The steam maximum conditions are determined by safety relief valves in the steam generating equipment or pressure regulating valves in the CPP. The trap return maximum conditions are determined from the same values since isolation valves in the system can keep these pressures to the corresponding steam conditions. The pumped return maximum condition is an estimate of the highest conceivable dead head pressure of a condensate return pump. The chilled water maximum pressure is the dead head point for the chilled water distribution pumps in the CPP and the cumulative static head pressure on the system.

b. "Normal Operating" conditions are the system conditions where the utilities leave the CPP or downstream of distribution pressure regulating stations. Actual available steam or chilled water pressure at buildings will be lower due to the pressure drop through the distribution system. For the normal and minimum available pressures available at each building, request this data from Yale Utilities. Do not look at a pressure gage at a building and assume that pressure will always be available – pressures can drop significantly seasonally when demand peaks.

2. Steam

a. General

1) Steam is distributed at various pressures. For new projects, discuss available

pressures with Yale Utilities.

2) For thermal stress analyses, consider the install temperature to be no higher than 50 deg F. If work is to be installed outdoors, unprotected from the elements during the winter period, consider lowering the install temperature to something more appropriate.

b. High Pressure Steam: Designate this system as "HPS"

1) HPS – 250 PSIG (Primarily in Science Hill distribution from CPP)

a) Maximum Design Pressure and Temperature: 300 PSIG at 410 deg. F
b) Normal Operating Pressure and Temperature: 250 PSIG at 406 deg F (saturated)

2) HPS – 125 PSIG (Primarily in Central Campus distribution from CPP and all HPS of SPP)

a) Maximum Design Pressure and Temperature: 150 PSIG at 366 deg F (saturated)
b) Normal Operating Pressure and Temperature: 125 PSIG at 353 deg F (saturated)

c. Medium Pressure Steam: Designate this system as "MPS". For each project, refer to Yale Utilities for possibly using "Maximum Design Pressure and Temperature" conditions for HPS system so that in the future, the piping system can be converted to HPS with no modifications except for replacing steam traps and re-insulating. This way, the new piping system will be designed for thermal expansion and pressure and temperature for the higher conditions.

1) MPS – 70 PSIG (Primarily in Science Hill distribution from CPP)

a) Maximum Design Pressure and Temperature: 80 PSIG at 324 deg F (saturated)
b) Normal Operating Pressure and Temperature: 70 PSIG at 316 deg F (saturated)

2) MPS – 30 PSIG (Primarily in Central Campus distribution from CPP)

a) Maximum Design Pressure and Temperature: 40 PSIG at 287 deg F (saturated)
b) Normal Operating Pressure and Temperature: 30 PSIG at 274 deg F (saturated)

d. Low Pressure Steam: Designate this system as "LPS" (Primarily in Central Campus distribution from CPP and all LPS of SPP). For each project, refer to Yale Utilities for possibly using "Maximum Design Pressure and Temperature" conditions for HPS or MPS system so that in the future, the piping system can be converted to HPS or MPS with no modifications except for replacing steam traps and re-insulating. This way, the new piping system will be designed for thermal expansion and pressure and temperature for the higher conditions.

1) Maximum Design Pressure and Temperature: 20 PSIG at 259 deg F (saturated)
2) Normal Operating Pressures and Temperature: 10 PSIG at 239 deg F (saturated)

3. Condensate Return

a. General

1) Condensate return consists of trap returns from the distribution system and pumped returns from the buildings and distribution steam condensate return packages. In some cases, trap condensate from the distribution system is connected directly to the pumped return line. This is no longer allowed and all existing connections of this type are being retrofitted. If you discover this condition in an area where you are performing design, please ask Yale Utilities if it should be retrofitted. All high pressure and medium pressure distribution trap returns shall be flashed in tunnels to low pressure steam systems (complete with relief valve) and all low pressure traps shall be gravity returned.
2) For thermal stress analyses, consider the install temperature to be no higher than 50 deg F.

b. Trap Returns

1) All trap returns design and operating pressures and temperatures shall match the steam conditions, i.e., trap returns from an "HPS" steam trap shall have maximum design pressure and temperature of 300 PSIG at 410 deg. F.
2) Trap return piping shall be labeled as follows:

a) From "HPS" traps: "HPC" for high pressure condensate or "HPR" for high pressure return.
b) From "MPS" traps: "MPC" or "MPR".
c) From "LPS" traps: "LPC" or "LPR".

3) Where trap returns from different pressure systems join together upstream of a flash tank to atmosphere where they can be valved off, all of the trap return piping shall be designed for the higher pressure system.

c. Pumped Returns: Shall be labeled as "PC". Refer to "Condensate Return Units" for design of pumps.

1) Maximum Design Pressure and Temperature: 75 PSIG at 212 deg F. Note that in cases where trap returns discharge into the pumped return line, consideration should be made to increase the maximum design pressure to the trap system conditions.
2) Normal Operating Pressure and Temperature: Determine from Yale Utilities per the "Condensate Return Units" paragraph.

4. Chilled Water

a. Shall be labeled as "CHWS" and "CHWR".

b. Design Temperatures: Supply temperatures shall be approximately 42 deg F in the summer and 44 deg F in the winter. For thermal stress analyses, consider the install temperature to be no lower than 70 deg F.

c. Maximum Design Pressure and Temperature: 150 PSIG at 100 deg F.

d. Normal and Minimum Operating Pressures: Determine from Yale Utilities. They are estimated to be between 60 to 150 PSIG.

C. VELOCITY AND PRESSURE DROP LIMITS

1. General

Pipes shall be sized to satisfy the more restrictive condition of velocity or pressure drop. In areas where noise may be an issue (basements or mechanical rooms), size lines for slower velocities.

2. Steam

   a. HPS and MPS Systems

      1) For 4” piping and lower: Maximum velocity shall be 8,000 FT/MIN. Maximum pressure drop shall be 0.5 PSID / 100 FT.
      2) For piping larger than 4”: Maximum velocity shall be 12,000 FT/MIN. Maximum pressure drop shall be 0.5 PSID / 100 FT.

   b. LPS System

      1) For 4” piping and lower: Maximum velocity shall be 4,000 FT/MIN. Maximum pressure drop shall be 0.5 PSID / 100 FT.
      2) For piping larger than 4”: Maximum velocity shall be 8,000 FT/MIN. Maximum pressure drop shall be 0.5 PSID / 100 FT.

3. Condensate Return

   a. Trap Returns: Maximum velocity shall be 4,000 FT/MIN in consideration of two phase flow. Maximum pressure drop shall be 1 PSID / 100 FT.

   b. Pumped Returns: Maximum velocity shall be 10 FT/SEC. Maximum pressure drop shall be 1 PSID / 100 FT.

4. Chilled Water

      1) For 2” piping and lower: Maximum velocity shall be 4 FT/SEC.
      2) For 2-1/2” piping and larger: Maximum velocity shall be 8 FT/SEC.
      3) Maximum pressure drop shall be 4 FT HD / 100 FT.

D. SYSTEM SPECIFICATIONS

1. General

   Piping shall be as specified for each particular system. Victaulic, fiberglass, and FRP piping are not acceptable.

2. Country of Fabrication / ISO Registration

   All piping, fittings, and specialties including expansion joints, strainers, etc. shall be manufactured, fabricated, and assembled in the United States or Canada, or they shall be by an ISO 9001 registered corporation. No piping, fittings, or specialties manufactured, fabricated, and/or assembled in China, Taiwan, or India are permitted on any project including those companies registered with ISO 9001.

3. HPS, MPS, LPS Systems Specification

   a. Pipe

      All pipe 2 inches and smaller shall be seamless carbon steel conforming to ASTM A 106, Grade B. All pipe 2-1/2 inches through 24 inches shall be seamless carbon steel conforming to ASTM A 106, Grade B. Pipe wall thickness shall be Schedule “XS” for 1/8" through 2" NPS pipe size and Schedule "STD" for 2-1/2” through 24”. All threaded pipe nipples shall be Schedule "XS" conforming to ASTM A 106, Grade B.

   b. Joints

1) Joints 2 inches and smaller shall be socket welded.
2) Joints 2-1/2 inches and larger shall be butt welded.
3) All sizes shall be flanged where required to connect to flanged valves, fittings, or equipment.

c. Flanges

Flanges 24 inches and smaller shall be Class 300 welding neck type in accordance with ASME B16.5 and raised faced or as required to match the mating flange. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.

d. Gaskets

Gaskets shall be spirally wound, Type 316L stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/8 inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexite Super Filler, manufactured by Flexitallic Inc., 6915 Hwy. 225, Deer Park, TX 77536; Phone Number (281) 479-3491; or approved equal.

e. Fittings

1) Fittings 2 inches and smaller shall be 3000 pound socket-weld in accordance with ASME B16.11. Material shall conform to ASTM A 105.
2) Fittings 2-1/2 inches and larger shall be steel butt-welding type in accordance with ASME B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.
3) Mitered branches may be used when reinforced according to ASME B31.1. Reinforcing shall consist of increased header thickness, increased outlet pipe thickness, strap or weld type reinforcement, welding type reinforcing saddles, or a combination of these methods.

f. Bolting Materials

Bolting materials shall be continuous threaded alloy steel studs threaded in accordance with ASME B1.1, Class 2A. Material shall conform to ASTM A 193, Grade B7. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished and in accordance with ASME B18.2.2 and B1.1, Class 2B. Material shall conform to ASTM A 914, Grade 2H.

g. Unions

1) Unions 2 inches and smaller shall be 3000 pound forged steel socket weld with steel to steel seats. Material shall conform to ASTM A 105.
2) Unions 2-1/2 inches and larger shall be made with flanges.

4. HPC, MPC, and LPC System Specifications

Shall be the same as the “HPS, MPS, and LPS” system specifications except all pipe and fittings shall be Schedule “XS” for all sizes.

5. PC System Specifications

a. Pipe

All pipe shall be electric resistance welded carbon steel conforming to ASTM A 53, Grade B. Pipe wall thickness shall be Schedule "XS" for 3/4" through 24". All threaded pipe nipples shall be Schedule "XS" conforming to ASTM A 106, Grade B.

b. Joints

1) Joints 2 inches and smaller shall be socket welded.
2) Joints 2-1/2 inches and larger shall be butt welded.
3) All sizes shall be flanged where shown on the Contract Drawings or where required to connect to flanged valves, fittings, or equipment.

c. Flanges

Flanges 24 inches and smaller shall be Class 150 welding neck type in accordance with ASME B16.5 and raised or flat faced as required to match the mating flange. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.

d. Gaskets

Gaskets shall be spirally wound, Type 316L stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/8 inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexite Super Filler, manufactured by Flexitallic Inc., 6915 Hwy. 225, Deer Park, TX 77536; Phone Number (281) 479-3491; or approved equal.

e. Fittings

1) Fittings 2 inches and smaller shall be 3000 pound socket-weld in accordance ASME B16.11. Material shall conform to ASTM A 105.
2) Fittings 2-1/2 inches and larger shall be steel butt-welding type in accordance with ASME B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.
3) Mitered branches may be used when reinforced according to ASME B31.1. Reinforcing shall consist of increased header thickness, increased outlet pipe thickness, strap or weld type reinforcement, welding type reinforcing saddles, or a combination of these methods.

f. Bolting Materials

Bolting materials shall be continuous threaded alloy steel studs threaded in accordance with ASME B18.2.1. Material shall conform to ASTM A 193, Grade B7. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished and in accordance with ASME B18.2.2. Material shall conform to ASTM A 194, Grade 2H.

g. Unions

1) Unions 2 inches and smaller shall be 3000 pound forged steel socket weld with steel to steel seats. Material shall conform to ASTM A 105.
2) Unions 2-1/2 inches and larger shall be made with flanges.

6. CHWS and CHWR System Specifications

a. Pipe

1) All pipe 2 inches and smaller shall be Type L drawn temper copper per ASTM B 88. As an option, pipe shall be electric resistance weld carbon steel conforming to

ASTM A 53, Grade B, Schedule “STD”. All threaded carbon steel pipe nipples shall be Schedule "XS" conforming to ASTM A 106, Grade B.

2) All pipe 2 -1/2 inches through 24 inches shall be electric resistance weld carbon steel conforming to ASTM A 53, Grade B. Pipe wall thickness shall be Schedule "STD" for all pipe sizes.

b. Joints

1) Joints 2 inches and smaller shall be threaded for carbon steel.
2) Joints 2-1/2 inches and larger shall be butt welded.
3) All sizes shall be flanged where required to connect to flanged valves, fittings, or equipment.

c. Flanges

Flanges 24 inches and smaller shall be Class 150 welding neck type in accordance with ASME B16.5 and raised or flat faced as required to match the mating flange. Material shall conform to ASTM A 105. Welding neck flanges shall be bored to match the same ID as the attached pipe.

d. Gaskets

Gaskets shall be spirally wound, Type 316L stainless steel with non-asbestos filler material and carbon steel outer ring. Gaskets shall be 1/8 inch thick and conform to the flange face on which they are used. Acceptable products from acceptable manufacturers include: Flexitallic Style CG with Flexite Super Filler, manufactured by Flexitallic Inc., 6915 Hwy. 225, Deer Park, TX 77536; Phone Number (281) 479-3491; or approved equal.

e. Fittings

1) Fittings 2 inches and smaller shall be 150 pound screwed banded malleable iron threaded in accordance with ASME B16.3. Material shall conform to ASTM A 197.
2) Fittings 2-1/2 inches and larger shall be steel butt-welding type in accordance with ASME B16.9 and with the same wall thickness as the attached pipe. Material shall conform to ASTM A 234, Grade WPB.
3) Mitered branches may be used when reinforced according to ASME B31.1. Reinforcing shall consist of increased header thickness, increased outlet pipe thickness, strap or weld type reinforcement, welding type reinforcing saddles, or a combination of these methods.

f. Bolting Materials

1) Bolting materials shall be continuous threaded alloy steel studs threaded in accordance with ASME B18.2.1. Material shall conform to ASTM A 193, Grade B7. Nuts shall be heat-treated, heavy, hexagonal nuts, semi-finished and in accordance with ASME B18.2.2. Material shall conform to ASTM A 194, Grade 2H.
2) Bolting materials shall be mild steel, hexagonal head bolts with heavy hexagonal nuts conforming to ASTM A 307, Grade B.

g. Unions

1) Unions 2 inches and smaller shall be 150 pound malleable iron, brass seat, nut type. Material shall conform to ASTM A 197.

2) Unions 2-1/2 inches and larger shall be made with flanges

E. STRAINERS

1. Steam and Condensate Systems

a. General

1) Strainers for steam service shall be "Y" type. Note that all strainers upstream of a steam trap are considered to be in the steam service, not condensate service.
2) Provide a screen blowdown valve for each strainer. The valve shall be the full size of the blow-off tap. Provide shut-off valve. Provide nipple with cap downstream of valve. Select the length of the nipple connecting the blow-off valve to the strainer basket connection so that the blow-off valve is clear of the insulation.
3) Provide strainer screen with a minimum net free area of 2 1/2 times the cross-sectional area of the entering pipe.
4) Install steam strainers horizontally on their side with screen chamber at the 3 or 9 o'clock position. Install all other strainers horizontally with the screen chamber at the 6 o'clock position. Install strainers vertically only when required and when the direction of flow is down.

b. Strainer Screens: All strainer screens shall be minimum 1/8 inch thick Type 316 Stainless Steel.

1) Steam service strainers shall have 3/64 inch mesh perforations unless otherwise required by the valve or device which it protects.
2) Condensate service strainers shall have mesh perforations as follows:

a) ½” thru 2” NPS 0.057 inch openings
b) 2-1/2” thru 4” NPS 0.125 inch openings
c) 5” NPS and over 01.25 inch to 0.25 inch openings

c. HPS, MPS, LPS, HPC, MPC, and LPC Systems Construction

1) Sizes 2 inches NPS and below: Body shall be carbon steel in accordance with ASTM A 216, Grade WCB. Strainer shall be ANSI Class 300 and shall have a design pressure of 300 psig at 450 degrees F. Connections shall be threaded. Strainer body size and connections shall not be below 1 inch NPS.
2) Sizes 2-1/2 inches NPS and above: Body shall be carbon steel in accordance with ASTM A 216, Grade WCB. Strainer shall be ANSI Class 300 and shall have a design pressure of 300 psig at 450 degrees F. Connections shall be ANSI Class 300 flanged.

2. CHWS and CHWR Systems

a. General

1) Strainers for chilled water service shall be inline, scraping type for cleaning with manual handwheel by Hellan Strainer Company of Cleveland, Ohio. Provide number of screens as required for the piping size.
2) Provide strainers at inlet of buildings prior to the delta P valve.

b. All strainer screens shall be minimum 1/8 inch thick Type 316 Stainless Steel.

1) Strainers shall have mesh perforations as follows:

a) ½” thru 2” NPS 0.057 inch openings
b) 2-1/2” thru 4” NPS 0.125 inch openings

c) 5” NPS and over 01.25 inch to 0.25 inch openings

c. General

1) Sizes 2 inches NPS and below: Body shall be heavy duty cast iron in accordance with ASTM A 126 Class B. Strainer shall be ANSI Class 250 and shall have a design pressure of 250 PSIG at 406 deg. F. Connections shall be threaded.
2) Sizes 2-1/2 inches NPS to 6 inch NPS: Body shall be heavy duty cast iron in accordance with ASTM A 126 Class B. Strainer shall be ANSI Class 125 and shall have a design pressure of 125 PSIG at 353 deg. F. Connections shall be Class 125 flanges.
3) Sizes 8 inch NPS and above: Body shall be carbon steel in accordance with ASTM A 216, Grade WCB. Strainer shall be ANSI Class 150 and shall have a design pressure of 300 psig at 450 degrees F. Connections shall be ANSI Class 300 flanged.

F. VALVES

1. General

a. Provide valves as stated below. Do not provide any cast iron valves.

b. Operators: Provide the following special operator features:

1) Handwheels, fastened to valve stem, for valves other than quarter turn.
2) Lever handles, on quarter-turn valves 6 inch and smaller, except for plug valves. Provide plug valves with square heads.
3) Chain-wheel operators, for all valves installed 6 feet or higher above finished floor. Extend chains to an elevation of 5 feet above finished floor.
4) Gear drive operators with and wheels where indicated.

c. Extended Stems: Where insulation is indicated or specified, provide extended stems arranged to receive insulation.

d. By-pass and Drain Connections: Provide valved by-pass where indicated on the Contract Drawings. Comply with MSS SP-45 bypass and drain connections.

2. Wet Tap/ Hot Tap Valves

The Contractor shall provide hot taps into existing mains that will remain energized at up to the piping system design pressure where a hot tap is specifically indicated in the Contract Drawings. This procedure is also known as wet tapping or hot tapping. For these instances, the valve shall be a full port valve to satisfy the requirements of the hot tap machine and provide a true area pipe tap, and shall satisfy the requirements of the specification of the valve group. The valve selection must be approved by the hot tapping company.

3. HPS, MPS, LPS, HPC, MPC, and LPC Systems

a. Shut-off Service

1) 2” and Smaller: Ball valve be Class 300, rated for saturated steam service, carbon steel body with 316 stainless steel ball and stem, carbon and graphite filled TFE (Nova) seats and seals. Valve shall be rated for cold water pressure of 1480 PSIG and maximum temperature of 550 deg F. Valve shall have screwed ends. Valve shall have standard bore size. Valve shall have precision engineered solid stainless steel ball with relief hole in stem slot to prevent build up of cavity pressure while

valve is in open position. Bi-directional floating ball seats downstream reduce torque and guarantee a bubble-tight shut off. Valve shall have three piece body and shall be in-line serviceable swing-out center section that allows easy access to internal valve components without disturbing alignment of pipe. Body shall be held together with the assist of Belleville washers. Valve shall have live loaded stem. Valve shall have blow-out proof stem design and shall have zinc plated carbon steel lever with vinyl grip. Valve lever shall have design so that lock-out can easily occur. Valves shall be Sharpe Series F84 high performance.

2) 2-1/2" and Larger: High performance butterfly style, ANSI Class 300 carbon steel body conforming to ASTM A105 or A216, Type WCB type position indicator for sizes 2-1/2" through 24". Provide gear operator and chain wheel for all sizes. Triple seated, offset seat with eccentric disc, flanged body, with 316 stainless steel disc, 17-4 PH stainless shaft, and metal seats. Flanges shall be Class 300 per ASME B16.5 and material shall be ASTM A105. Valve and valve seat shall be designed and rated for steam service at pressure and differential pressures (both ways) to 300 PSIG saturated steam. Rating of valve shall be bi-directional ANSI Class V. Valves shall be pre-set at the factory for zero leakage – valve operators must be factory installed so they are ready for installation and the closed position is set. Valve shall be Vanessa or Velan.

b. Throttling Service for Warm-Up

1) 2" and Smaller: Same spec as shut-off service.
2) 2-1/2" and Larger: Same spec as shut-off service.

c. Check Valve Service: Shall be spring-loaded disc with 316 SS body and trim. Shall be Gestra, Model RK86.

4. PC System

a. Shut-off Service

1) 2" and Smaller: Ball valve rated for 150 PSIG saturated steam pressure, 2000 PSIG WOG pressure for 1/4" through 1", 1500 PSI WOG pressure for 1-1/2" through 2"; two piece construction, with carbon steel body, regular port, 316 SS ball and stem, replaceable "Teflon" or "TFE" seats and seals, blowout proof stem, vinyl covered steel handle, screwed ends and extended stem for insulated piping.
2) 2-1/2" and Larger: Butterfly style (not high performance), ANSI Class 150 carbon steel body conforming to ASTM A105 or A216, Grade WCB type position indicator for sizes 2-1/2" through 24". Provide gear operator and chain wheel for all sizes. Single seated, offset seat with eccentric disc, flanged body, with 316 stainless steel disc, 17-4 PH stainless shaft, and metal seats. Flanges shall be Class 150 per ASME B16.5 and material shall be ASTM A105. Valve and valve seat shall be designed and rated for steam service at pressure and differential pressures (both ways) to 150 PSIG saturated steam. Rating of valve shall be bi-directional ANSI Class V. Valves shall be pre-set at the factory for zero leakage – valve operators must be factory installed so they are ready for installation and the closed position is set. Valve shall be Vanessa or Velan.

b. Throttling Service

1) 2" and Smaller: Same spec as shut-off service.
2) 2-1/2" and Larger: Same spec as shut-off service.

c. Check Valve Service: Shall be spring-loaded disc with 316 SS body and trim. Shall be

Gestra, Model RK86.

5. CHWS and CHWR Systems

a. Shut-off and Service

1) 2” and Smaller: Screwed 275 pound WOG ball valve, bronze body and ball to ASTM B 62, replaceable teflon seats and seals, screwed ends, lever operated with stops at full open and full closed positions.
2) 2-1/2” and Larger: ANSI Class 150 high performance butterfly valve with bubble light (zero leakage) shut off for 285 psig differential in either direction at design temperatures. There shall be no seat/disc contact in the open or intermediate position. Valve shall have tight shut-off in either direction. Triple seated, offset seat with eccentric disc. Body shall be carbon steel with 316 stainless steel disc and TFE seat. Shaft shall be 316 stainless steel. End connection shall be lugged design. Valves through 8 inches shall be equipped with a lever operator that provides a positive latch in the full open and full closed position as well as intermediate positions. Valves, 10 inches and larger, shall be equipped with a manual enclosed gear operator. Valve face to face dimensions shall be to API 609 and MSS SP 658. Valve shall be equipped with OSHA approved lock-out. Valve shall be rated for bi-directional flow and dead-end service, ANSI Class V. Valves shall be pre-set at the factory for zero leakage – valve operators must be factory installed so they are ready for installation and the closed position is set. Valve shall be Vanessa or Velan.

b. Throttling Service

1) 2” and Smaller: Same spec as shut-off service.
2) 2-1/2” and Larger: Same spec as shut-off service.

c. Check Valve Service

1) 2” and Smaller: Class 125 horizontal swing check valve, cast bronze body and cover, screwed ends, bronze seat and disc, screwed cover, integral seat, body and cover material to conform to ASTM B 61 or B 62. The valve shall conform to MSS SP-80, Class 150-B62, Type 3.
2) 2-1/2” and Larger: Class 150 steel horizontal swing check valve, flanged ends, bolted flanged cover and renewable seat ring. Body material shall conform to ASTM A 216, Grade WCB or A 105. Disc or disc seating face and the seat ring shall be 13 percent chromium stainless steel. Face to face dimension shall conform to ASME B16.10. Flange shall be faced and drilled to ASME B16.5. Working pressure and temperature ratings shall comply with ASME B16.34 (Standard Class).

G. STEAM TRAPS, DRAINAGE, AND VENTING

1. Steam Traps

a. General

1) Locate steam trap stations at all low points and in no case more than 500 feet apart. It is preferred that steam traps be located 300 feet apart.
2) Refer to Detail 7-1 for typical piping details for steam trap stations and drip legs.
3) Provide steam trap stations and dirt legs on both sides of isolation valves where there is a potential that steam could be back-fed from another source. There are many instances on campus where there are redundant feeds. If there is any

question, ask Yale Utilities.

4) All steam traps shall be scheduled on drawings. Do not leave it up to the Contractor to select a steam trap.
5) All steam traps shall be numbered in a manner as designated by Yale Utilities for record keeping purposes associated with maintenance. The designation shall be "STP-XXX-XX". The steam trap number shall be on a stainless steel tag connected to the steam trap.

b. HPS and MPS Systems

1) Type: Thermostatic type with membrane regulator and built-in strainer with blowdown valve and built-in check valve.
2) Construction

a) General: Traps shall be designed for 300 psig, 750 degree F. All stainless steel internals.
b) Body: ASTM A 105.
c) Connections: Size of connection shall depend on the flow requirements. Type of connection shall be screwed.

3) Acceptable Manufacturers: Gestra (Flow Serve) Model MK 45-1 or Armstrong.

c. LPS System

1) Type: Float and thermostatic type. Thermostatic control capsule shall allow automatic deaeration.
2) Construction

a) General: Traps shall be designed for 30 psig, 275 degree F steam conditions. Internals shall be brass and stainless steel.
b) Body: Cast iron, Class 250.
c) Connections: Minimum connection size is 1 inch NSP. Type of connection shall be screwed.

3) Acceptable Manufacturers: Gestra (Flow Serve) UNA 30 F&T or Armstrong.

2. Drainage and Venting

a. Drainage of low points in steam piping shall be through the drip leg of the steam trap station. Provide 2" shut-off valves with screwed caps at all drip legs and at all low points in main trap return pipes and pumped condensate return mains.

b. Provide 1" shut-off valves with a screwed cap at all high points in steam and condensate piping.

H. CHILLED WATER SPECIALTIES

1. Manual Air Vents

Manual air vents shall be ¾ inch NPS manual ball valve as specified in Valves with ¾ inch NPS pipe piece at outlet with female cap.

2. Automatic Air Vent

Automatic air vents shall be located at ends of pipes prior to the isolation valves leading to buildings. They shall be designed to vent automatically with float principle; cast iron body and nonferrous internal parts; 150 PSIG working pressure, 100 deg F maximum operating temperature; with ¼ inch NPS discharge connection and ½ inch NPS inlet connection. Provide air vents from Armstrong.

I. STEAM PIPING CONSIDERATIONS

1. General

a. Isolation valves shall be provided on steam systems no more than every 1,000 feet or every fourth manhole. (This requirement may be tighter per Yale Utilities depending on the design.) This allows steam piping to be started up in segments. At each isolation valve, provide a 2” warm-up valve (globe style) across the isolation valve with a pressure gage and isolation valves across both sides so that an Operator can see the upstream pressure and downstream pressure. Refer to Detail 7-2. Provide drip legs and steam trap stations on both sides of the isolation valve if steam can originate from both sides. If there is any doubt where steam can flow from, ask Yale Utilities.

8. WELDING

A. WELDING REQUIREMENTS

1. General

a. Weld pipe joints only when ambient temperature is above 0 degree F where possible.

b. Bevel pipe ends at a 37.5 degree angle where possible, smooth rough cuts, and clean to remove slag, metal particles, and dirt.

c. Use pipe clamps or tack-weld joints with 1 inch long welds; 4 welds for pipe sizes to 10 inches, 8 welds for pipe sizes 12 inches to 20 inches.

d. Build up welds with stringer-bead pass, followed by hot pass, followed by cover or filler pass. Eliminate valleys at center and edges of each weld. Weld by procedures which will ensure elimination of unsound or unfused metal, cracks, oxidation, blow-holes, and non-metallic inclusions.

e. Do not weld-out piping system imperfections by tack-welding procedures; refabricate to comply with requirements.

f. If piping component ends are bored, such boring shall not result in the finished wall thickness after welding less than the minimum design thickness.

g. The inside diameters of piping components to be butt-welded shall be aligned as accurately as is practicable within existing commercial tolerances on diameters, wall thickness and out of roundness. Alignment shall be preserved during welding. The internal misalignment of the ends to be joined shall not exceed 0.05 inch.

2. Welding Processes

a. All welding on metal piping systems shall be performed using qualified welding procedures and qualified welders and welding operators in accordance with Section IX of the ASME Boiler and Pressure Vessel Code.

b. All welding shall be performed by a process that is compatible with the work being welded and the working conditions. Shielded metal-arc welding (SMAW) shall not be used on work less than 3/16 inch thick.

c. Work thicker than 3/16 inch shall have a root pass by the GTAW process with the back purged with argon and the balance of the weld may be completed by the SMAW process or other process as stated below.

d. Welding shall be performed by using only one of the following processes:

1) Shielded Metal Arc Welding (SMAW), also known as "Stick" Welding
2) Gas Turgsten Arc Welding (GTAW), also known as TIG and Heliarc Welding
3) Submerged Arc Welding (SAW)
4) Metal Inert Gas Welding (MIG)

e. Spray Rustoleum on welds after welding to prevent rust.

3. Welding Grooves

a. The ends of steel pipe and fittings to be erected with butt welded joints shall be beveled to form welding grooves in accordance with ASME B16.25.

b. Welding grooves for butt welded joints in pipe of unequal wall thickness shall be beveled in accordance with ASME Code for Pressure Piping B31.1.

4. Backing Rings

Backing rings shall not be used.

5. Cleaning of Welding

All slag or flux remaining on the bead of welding shall be completely removed before laying down the next successive bead and at the completion of the weld.

6. Weld Quality

a. All welds shall have full penetration and complete fusion with a minimum of weld metal protruding on the inside of the pipe.

b. The finished weld contour shall be uniform, with the toe or edge of the weld merging smoothly into the base material. Butt welds shall have a slight reinforcement build-up gradually from the toe or edge toward the center of the weld. The limitation on butt weld reinforcement shall be in accordance with ASME B31.1, Table 127.4.2 and shall apply separately to both inside and outside surfaces of the joint. Fillet welds may be slightly concave on the furnished surface.

7. Socket Welding Joints

Where socket welding valves or fittings are used, the pipe shall be spaced with a minimum of 1/16 inch clearance between the end of the pipe and the socket so that no stresses will be imparted to the weld due to "bottoming" of the pipe in the socket. The fit between the socket and the pipe shall conform to applicable standards for socket weld fittings and in no case shall the inside diameter of the socket exceed the outside diameter of the pipe by more than 0.075 inches.

B. WELDER QUALIFICATIONS

1. Welding Procedures

In the form of a submittal, the Contractor shall record in detail and shall qualify the Welding Procedure Specifications for every welding procedure that he proposes. Procedures shall be developed for all metals included in the work. The procedures for making transition welds between different materials or between plates or pipes of different wall thickness shall be qualified. Qualification for each welding procedure shall conform to the requirements of ASME B31.1, and to this specification. The method for each system shall be fully described including the number of beads, the volts, the amperes, and the welding rod for various pipe thicknesses and materials. The welding procedures shall specify end preparation for butt welds including cleaning, alignment, and root openings. Preheat, interpass temperature control, and postheat treatment of welds shall be as required by approved welding procedures, unless otherwise indicated or specified. Approval of any procedure does not relieve the Contractor of the sole responsibility for producing acceptable welds. Welding procedures shall be identified individually and shall be clearly referenced to the type of welding required for this project. These procedures shall be the same as those used for all pipe welder qualification tests, all shop welds, and all field welds. The Contractor shall provide Procedure Qualification Records for all proposed Welding Procedure Specifications (WPS).

2. Welding Procedure Submittals

   Submit the following:

   a. Welding Procedure Specifications: Provide for each weld type. It is highly recommended that the Contractor use ASME Form E00006, QW-482 "Suggested Format for Welding Procedure Specification (WPS)".

   b. Procedure Qualification Records: Provide for each weld type. It is highly recommended that the Contractor use ASME Form E00007, QW-483 "Suggested Format for Procedure Qualification Record (PQR)".

3. Welder Qualification

   a. WPQs: Provide welder qualifications for each welder for each weld type. It is highly recommended that the Contractor use ASME Form E00008, QW-484 "Suggested Format for Manufacturer's Record of Welder or Welding Operation Qualification Tests (WPQ)." The WPQs shall be performed under the witness of an independent agency. The witness shall be a representative of an independent testing agency, Authorized Inspector, or consultant, any of which must be approved by the National Certified Pipe Welding Bureau. The qualifying test segment must be a 2 inch nominal pipe size with wall thickness within range of the WPS. Tests position shall be "6G" per ASME Section IX.

   b. Evidence of Continuity: Welder qualifications must be current. If the qualification test is more than 6 months old, provide record of welding continuity for each welder. Record of welding continuity shall show that the welder in question has performed welding to the procedure in question without a 6 month continuous span of inactivity since the date that the welder qualification test was passed for the submitted welding procedure. Record of welding continuity shall include, at a minimum, the welder's employer name and address, the date the welder qualification test was passed, and the dates indicating welding continuity including welding procedure for each date.

   c. In lieu of providing WPQs and Evidence of Continuity, the Contractor may elect to have all welders qualified on-site by an Independent Testing Agency prior to beginning work. This may be required by Yale Utilities, especially on larger projects.

C. WELD RECORDS

1. General

   a. For all welding within the scope of ASME B31.1, the Contractor shall submit for approval an administrative procedure for recording, locating, monitoring, and maintaining the quality of all welds to be performed on the project. This quality control document record shall include but not be limited to drawings and schedules identifying location of each weld by individual number, identification of welder who performed each weld by individual welder's name, stamp number, date and WPS used.

b. After achieving qualification, but before being assigned work, each qualified person shall be assigned an identifying number by the Contractor that shall be used to identify all of his welds. A list of qualified persons with their respective numbers shall be submitted by the Contractor and shall be maintained accurately with deletions and additions reported promptly.

c. Upon completing a joint, the welder shall mark the pipe not more than 6 inches from the weld with the identifying number and the last two digits of the year in which the work was performed. Identification marks shall be made by using a rubber stamp or felt-tipped marker with permanent, weatherproof ink or other methods approved by the Engineer that do not deform the metal. For seam welds, identification marks shall be placed adjacent to the welds at 3-foot intervals. Identification by die stamps or electric etchers will not be allowed. The markers are to be provided by the Contractor. Substituting a map of welds with welders' names shall not be acceptable.

9. PIPE SYSTEM TESTING AND CLEANING

A. CLEANING

1. General

a. All new piping shall be cleaned. Refer to Yale Utilities for each project and they will consult with their chemical treatment supplier (is Nalco as of October 2007). Note that this may include a steam blow, slug flush, chemical treatment, or some other means.

B. HYDROSTATIC REQUIREMENTS

1. General

a. Provide hydrostatic testing for all new piping systems and modifications to any existing piping systems, including pipe or valve replacement and any changes to anchors. In some instances when connecting piping must be maintained in a hot condition, hydrostatic testing may not be possible for the entire pipe length. The Engineer shall consider this in the phasing plan on the documents to ensure that most all components are tested per ASME B31.1. Under no circumstance will hydrostatic testing be waived where expansion joints are involved.

b. Provide temporary equipment for testing, including pump and gages. The gage shall be accurate to within 3 psig and shall be calibrated within six months of the test as recorded on a sticker on the gage. Test piping system before insulation is installed or piping is painted. Pressure testing shall be performed following the completion of nondestructive examinations, and all other fabrication, assembly, and erection activities required to the provide the system or portions thereof subjected to the pressure test with pressure retaining capability. Remove control devices before testing. Ensure that all expansion joints, anchors, and guides are installed and completed. Fill each section with water and pressurize for indicated pressure and time. The Contractor shall provide air vent valves at all high points in the system to purge air pockets while the system is filling and drain valves at all low points to drain system.

c. The Contractor shall consider that testing may be performed against existing valves and equipment having unknown sealing capability. It is the Contractor's responsibility to provide adequate pumping and test medium to accommodate any leakage through the existing equipment and valves.

d. Testing shall be performed with calibrated test gages (Contractor furnished) in the presence of the Owner or Engineer.

e. The Contractor shall furnish all temporary pipe, fittings, and pumps required to perform the tests.

f. Pipe hangers, snubbers, or restraints shall be blocked, disconnected, or pinned, as required, prior to pressure testing or cleaning and shall be restored to operating condition following such test.

g. Equipment and instruments shall be isolated and openings shall be plugged, as required, to accomplish the required testing and cleaning and to prevent over pressurizing connecting piping or equipment. Relief and safety valves shall be "gagged" or the valves removed and the respective nozzle blanked for testing of the associated equipment.

h. The equipment to which any piping system is attached shall not be subjected to any line tests. The test pressures apply to the piping materials as specified but shall not be assumed to apply to piping specialties, accessories, or equipment, including safety heads, rupture disks, relief valves, expansion joints, instruments, or filters. Items that may be damaged by the test pressure shall either be removed or blanked off.

i. Lines containing check valves shall have the source of test pressure located on the upstream side.

j. The system shall be filled with water; care being taken that air is completely vented from the top of system so that there are no air pockets remaining.

k. The test water for hydrostatic tests shall be clean and of such quality as to minimize corrosion of the materials in the piping system. The temperature of the test medium shall be a minimum of 60 degrees F, unless the Engineer specifies otherwise. The test pressure shall not be applied until the system and the pressurizing medium are approximately at the same temperature.

l. The leak test shall be considered satisfactory if no leakage is discovered on the piping or at any joints and if no sweating due to porosity is discovered on piping or at joints. Lines requiring repairing shall be retested to the pressure originally specified. The piping system, exclusive of possible localized instances at pumps or packing, shall show no evidence of leaking.

m. Repair piping systems sections which fail required piping test, by disassembly and re-installation, using new materials to extent required to overcome leakage. Do not use chemicals, stop-leak compounds, mastics, or other temporary repair methods.

n. Drain test water from piping systems after testing and repair work has been completed.

2. Test Pressure

a. The hydrostatic test pressure shall be as defined in Paragraph 137.4.5 of the ASME B31.1 Power Piping Code which is 1-1/2 times the maximum design pressure of the system. The design pressure is listed in Part 7.B. For example, a "HPS" pipe service has a maximum design pressure of 300 PSIG, therefore, the hydrostatic test pressure is

450 PSIG.

b. The test pressure shall be continuously maintained for a minimum time of 10 minutes and may then be reduced to design pressure (in the case for “HPS”, 300 PSIG) and held for such time as may be necessary to conduct the examinations for leakage. Examinations for leakage shall be made of all joints and connections. The piping system shall show no visual evidence of weeping or leaking.

3. Test Blinds

a. If during the field testing of piping it becomes necessary to insert test blinds in any part of this piping, the Contractor shall provide test blinds.

b. Test blinds shall be equipped with a long handle.

c. The Contractor shall submit a written description of the location of test blinds before testing.

d. The Contractor shall remove all test blinds after testing.

4. Records

a. It is the responsibility of the Contractor to keep accurate, updated records of all hydrostatic testing. The Contractor shall submit a final log of all hydrostatic testing for the Owner’s records.

b. The Contractor shall maintain a constantly updated list of the following for all hydrostatic tests:

1) Date and time of test.
2) Hydrostatic test pressure.
3) Piping system tested.
4) Extent of piping system tested so that it can be clearly identified up to what point a piping system has been tested.
5) Test results. All failures shall be indicated with the cause explicitly stated and the corrective action taken.
6) Signed witnesses of each test which shall be one employee of the Contractor and by the Owner or Engineer.

C. NON-DESTRUCTIVE TESTING

1. Visual Examination (VT)

a. General: ASME B31.1 requires that all welds be visually examined. Therefore, visually examine all pipe welds per ASME B31.1. As described below, visual examination of welds shall be performed by the Contractor and the records are not required to be reported to Yale.

b. Acceptance Standards

1) The acceptance standards for visual examination shall be as defined in ASME B31.1, Paragraph 136.4.2.A, and are repeated here for convenience. The following indications are unacceptable:

a) Cracks-external surface.
b) Undercut on surface which is greater than 1/32 inch deep.
c) Weld reinforcement greater than that specified in Table 127.4.2. of ASME B31.1.

d) Lack of fusion on surface.
e) Incomplete penetration (applies only when inside surface is readily accessible).
f) Any other linear indications greater than 3/16 inch long.

2) Surface porosity with rounded indications having dimensions greater than 3/16 inch or four or more rounded indications separated by 1/16 inch or less edge to edge in any direction. Rounded indications are indications which are circular or elliptical with their length less than three times their width.
3) In addition, acceptance will also be based on the proper lay-out, materials, and methods, as specified.

c. Failed Welds

1) All welds not passing visual examination shall be repaired or replaced at no expense to the Owner.
2) Do not begin to repair or replace the weld until the weld report has been submitted to the Engineer and the Engineer gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.
3) If a welder has three failed welds, he must be removed from the project.

d. Reporting

1) Reports preformed for visual examinations are not required to be submitted, but shall be kept available for review at any time by the Owner or Engineer.
2) Each weld report shall include the following:

a) Date of weld examination.
b) Type of examination.
c) Examiner's name.
d) Welders' names including all persons who worked on the weld and their work involved.
e) Piping system.
f) Weld location.
g) Weld procedure and materials.
h) Materials and dimensions of items that were welded.
i) Visual examination results.

e. Examiners' Qualifications

1) All persons performing visual examinations and evaluating examinations shall be certified according to the company’s welding policy.
2) Credentials and certification of all examiners must be submitted and approved prior to an examiner performing the initial examination.

f. Visual Examination Requirements

1) Welds designated for visual examination shall be examined as follows:

a) Before welding - for compliance with requirements for joint preparation, alignment and fit-up, cleanliness, condition of welding equipment, quality and condition of base and filler materials to be used, and preheat, when required.
b) During welding - for cracks, conformance to the qualified welding procedure, quality of individual weld passes, interpass temperature,

placement and sequencing of individual weld passes, and backgouged surfaces.
c) After welding - for cracks, contour and finish, bead reinforcement, undercutting, overlap, size of fillet welds, finished weld appearance, weld size, weld length, dimensional accuracy of weldment, and monitor post weld heat treatment.

2) Records of visual examinations must be kept as described in this Section.
3) Shop fabricated welds may be examined in the shop prior to arrival at the project site provided all other conditions of this Section are satisfied.

g. Examiner's Scope

1) Visual examinations to be performed by the Contractor may be performed and interpreted by an employee or employees of the Contractor, provided that each individual is certified as specified. As an option, the Contractor may obtain the services of an independent testing agency to perform these examinations.
2) If the Contractor elects to utilize the services of an independent testing agency to perform any visual examinations, the following applies:

a) The qualifications for the personnel of the independent testing agency performing the examinations shall be submitted.
b) The Contractor shall provide all required access and lighting for the independent testing agency.
c) The Contractor shall be responsible for all of the independent testing agencies activities, including handling submittals, performing evaluations at the required times, etc.

3) A welder who has performed any work with regard to a specific weld shall not perform the visual examination of the same weld.

2. Radiographic Examination (RT)

a. General

1) Although not required per the written code of ASME B31.1, Yale Utilities may require that some piping be radiographically examined in order to maintain quality of welding, especially for larger projects and/or on HPS systems. Confer with Yale Utilities to determine if a project requires RT and the quantity of RT required. Refer to Part 3 for testing required for direct buried systems. If Yale Utilities states that RT is required for piping in manholes and tunnels, the Engineer shall specify a number of welds to be tested via radiography examination – this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of welds and shall require testing of at least 10% of the estimated field welds (more if requested by Yale Utilities).
2) When RT is designated, butt welds and welded branch connections for sizes over NPS 2 shall be examined per the requirements specified herein.
3) Contractor shall count and document count of welds prior to testing to establish the percent of welds for each system and size category. Submit this documentation with weld testing written procedures prior to weld testing work.
4) Radiographic (gamma ray) testing shall be performed by an independent testing agency.

b. Acceptance Standards: Shall be in accordance with Paragraph 136.4.5 of ASME B31.1. The Engineer may, at his sole discretion, elect to waive some of the acceptance standards on a case by case basis.

c. Procedure

1) Radiographic examination shall be performed in accordance with Article 2 of Section V of the ASME Boiler and Pressure Vessel Code.
2) Submit written procedure as described in Paragraph T-221 of Article 2 of Section V of the ASME Boiler and Pressure Vessel Code.

d. Reporting

1) The report of each radiographic examination shall be submitted to the Engineer within 5 working days of the examination.
2) In addition to the requirements of Paragraph T-291 of Article 2 of Section V of the ASME Boiler and Pressure Vessel Code, each weld report shall include the following:

a) Date of weld examination.
b) Type of examination.
c) Examiner's name.
d) Welders' names including all persons who worked on the weld and their work involved.
e) Pipe system.
f) Weld location.
g) Weld procedure and materials.
h) Materials and dimensions of items that were welded.
i) Radiography examination results.

e. Examiner's Qualifications

1) All persons performing and evaluating radiographic examinations shall be certified for NDT Level II RT as recognized by the ASNT. A Nationally Certified level III RT technician per ASNT shall be on staff at the testing laboratory. A Corporate Level III RT without National Certification is not acceptable.
2) Credentials and certification of all examiners must be submitted and approved prior to a person performing the initial examination.

f. Radiographic Examination Requirements

1) The Contractor shall be responsible for obtaining and paying for the services of the independent testing agency. For the purposes of bidding and when a limited number of welds are specified to be tested (not 100%), the Contractor shall assume that the welds to be radiographically examined by the Independent Testing Agency shall be the largest pipe diameter for new piping indicated on the Contract Drawings and shall be located in the most difficult place to reach. The Contractor is responsible for providing access to the welds for the Independent Testing Agency.
2) When a limited number of welds are specified (not 100%), the welds to be examined shall be random. The Engineer shall designate the specific welds that are to be randomly tested as the job is in progress. The Contractor shall coordinate with the Engineer to ensure that these requirements are met.
3) It is suggested to the Contractor that the Contractor should notify the Engineer when welds that require scaffolding are complete so that the Contractor will not have to re-build scaffolding to gain access to the welds.
4) Shop fabricated welds will be examined in the field.

g. Failed Welds

1) All welds not passing radiography examination shall be repaired or replaced at no expense to the Owner.
2) Do not begin to repair or replace the failed weld until the weld report has been submitted to the Engineer and the Engineer gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.
3) All failed welds discovered by radiographic examination shall be re-examined by radiographic examination after the weld is repaired or replaced at no additional cost to the Owner.
4) When a weld is found defective, the Contractor shall test the weld repair via RT and shall also test an additional weld via RT as directed by the Engineer at no additional cost to Yale. If a welder has three failed welds, he must be removed from the project.

3. Magnetic Particle (MT) Examination

a. General

1) Although not required per the written code of ASME B31.1, Yale Utilities may require that some piping be examined by magnetic particle in order to maintain quality of welding, especially for larger projects and/or on HPS systems. Confer with Yale Utilities to determine if a project requires MT and the quantity of MT required. Refer to Part 3 for testing required for direct buried systems. If Yale Utilities states that MT is required for piping in manholes and tunnels, the Engineer shall specify a number of welds to be tested via magnetic particle examination – this shall be a hard number, not a percentage of welds so that the actual scope can be determined and tracked. The Engineer shall estimate the number of welds and shall require testing of at least 10% of the estimated field welds (more if requested by Yale Utilities).
2) Where MT is designated, butt welds, socket welds, and welded branch connections for sizes NPS 2 and less shall be examined per the requirements specified herein on the root and cap passes.
3) Contractor shall count and document count of welds prior to testing to establish the percent of welds for each system and size category. Submit this documentation with weld testing written procedures prior to weld testing work.
4) Magnetic particle testing shall be performed by an independent testing agency.

b. Acceptance Standards: Shall be in accordance with Paragraph 136.4.3 of ASME B31.1. The Engineer may, at his sole discretion, elect to waive some of the acceptance standards on a case by case basis.

c. Procedure

1) Magnetic particle examination shall be performed in accordance with Article 7 of Section V of the ASME Boiler and Pressure Vessel Code.
2) Submit written procedure as described in Paragraph T-721 of Article 7 of Section V of the ASME Boiler and Pressure Vessel Code.

d. Reporting

1) The report of each magnetic particle examination shall be submitted to the Engineer within 5 working days of the examination.
2) In addition to the requirements of Paragraph T-761 of Article 7 of Section V of the

ASME Boiler and Pressure Vessel Code, each weld report shall include the following:

a) Date of weld examination.
b) Type of examination.
c) Examiner's name.
d) Welders' names including all persons who worked on the weld and their work involved.
e) Pipe system.
f) Weld location.
g) Weld procedure and materials.
h) Materials and dimensions of items that were welded.
i) Magnetic particle examination results.

e. Examiner's Qualifications

1) All persons performing and evaluating magnetic particle examinations shall be certified for NDT Level II MT as recognized by the ANST. A Nationally Certified Level III MT technician per ASNT shall be on staff at the testing laboratory. A Corporate Level III MT without National Certification is not acceptable.
2) Credentials and certification of all examiners must be submitted and approved prior to a person performing the initial examination.

f. Magnetic Particle Examination Requirements

1) The Contractor shall be responsible for obtaining and paying for the services of the independent testing agency. For the purposes of bidding and when a limited number of welds are specified to be tested (not 100%), the Contractor shall assume that the welds to be magnetic particle examined by the Independent Testing Agency shall be the largest pipe diameter for new piping indicated on the Contract Drawings and shall be located in the most difficult place to reach. The Contractor is responsible for providing access to the welds for the Independent Testing Agency.
2) When a limited number of welds are specified (not 100%), the welds to be examined shall be random. The Engineer shall designate the specific welds that are to be randomly tested as the job is in progress. The Contractor shall coordinate with the Engineer to ensure that these requirements are met.
3) It is suggested to the Contractor that the Contractor should notify the Engineer when welds that require scaffolding are complete so that the Contractor will not have to re-build scaffolding to gain access to the welds.
4) Shop fabricated welds will be examined in the field.

g. Failed Welds

1) All welds not passing magnetic particle examination shall be repaired or replaced at no expense to the Owner.
2) Do not begin to repair or replace the failed weld until the weld report has been submitted to the Engineer and the Engineer gives approval for repairing the weld with the method that the Contractor proposes. Repair shall be performed using the qualified welding procedures applicable to the original weld.
3) All failed welds discovered by magnetic particle examination shall be re-examined by magnetic particle examination after the weld is repaired or replaced at no additional cost to the Owner.

4) When a weld is found defective, the Contractor shall test the weld repair via MT and shall also test an additional weld via MT as directed by the Engineer at no additional cost to Yale. If a welder has three failed welds, he must be removed from the project.

10. PIPE SUPPORTS AND THERMAL EXPANSION

A. GENERAL

1. Designer Responsibilities

a. Designers shall perform a thermal stress analysis and pipe support analysis and provide a complete design per ASME B31.1 including schedules and details of expansion joints, pipe supports, variable support spring hangers, constant support hangers, anchors, guides, etc. When connecting to existing piping, the Engineer shall field verify all existing conditions and include existing piping in his calculations that will affect his work and ensure that connecting to the existing piping system will keep the existing piping in conformance with the code. The Designer may have to re-engineer some components to the existing system including anchors, guides, and expansion joints to allow for a connection to the existing piping.

b. All structural support elements including pipe supports, guides, and anchors shall be engineered in compliance with ASME B31.1.

B. EXPANSION JOINTS

1. General

a. Expansion loops are the preferred means for compensation for thermal expansion. When routing utilities through tunnels, basements, and streets, the use of expansion joints may be considered where it will result in a lower installed cost. Approval for expansion joints must be granted by Yale Utilities.

b. Do not allow the shipping bands to be broken until the piping system is completely installed.

c. Do not allow hydrostatic testing or any pressurization of the piping system to take place until all piping work is completed and all guides, pipe supports, and especially anchors are completely installed.

d. All expansion joints shall be scheduled on the drawings which shall list the expansion joint number, thermal growth under normal and maximum conditions, and pressure thrust forces and system forces for maximum conditions and during hydrostatic pressure testing.

e. All expansion joints shall be numbered in a manner as designated by Yale Utilities for record keeping purposes associated with maintenance.

2. Externally Pressurized Expansion Joints

a. These types of joints are the only acceptable expansion joints for dealing with axial-only movement. Slip joints that require packing and bellows joints that are not externally pressurized are not allowed.

b. Application Notes

1) These joints cannot accept any non-axial loading. Do not connect any branch piping on a segment between the expansion joint and the pipe expanding in the joint. Branches shall be located at the anchors.
2) Do not place any bends in the piping with these joints except at the anchors.
3) Single ended expansion joints may have a base plate for weight support, but their base plate shall not be used as an anchor. Ensure that smaller bolts are used so that it is not installed as an anchor. Provide a separate anchor for single ended expansion joints. For double ended expansion joints, the base plate can be used as an intermediate anchor, but the anchor frame shall be designed for an end anchor condition in the event that a valve is placed in the system between the next anchor at a later time.
4) Anchors shall be designed for the worst case scenario of either hydrostatic pressure against the pressure thrust force, or the sum of the maximum design pressure against the pressure thrust force and the spring rate of the expansion joint and the resistance of the guides.
5) For piping systems that have externally pressurized expansion joints, the piping system must be laser aligned and the pipe supports must allow for alignment changes.
6) Ensure that there is adequate space for expansion joints. The length of expansion joints from one manufacturer to the next can differ significantly.
7) Consider actual pressure thrust area and/or spring rate of joint being supplied when checking submittal to ensure that the anchor is designed appropriately.
8) Regardless of whether the manufacturer's literature or salesperson states that a guide is not required within the first 5 pipe diameters of the expansion joint (because they claim the guide is internally guided), provide one anyway.

c. Specifications

1) Expansion joints shall be designed and installed in accordance with the most current edition of Expansion Joint Manufacturer's Association (EJMA) standards.
2) Expansion joints shall be rated for 1,000 full pressure/temperature cycles to 300 PSIG, saturated steam. All expansion joints for steam and condensate shall be designed and rated for 300 PSIG, saturated steam regardless of service.
3) Material: Bellows shall be constructed of ASTM A240 Grade 321 stainless steel, of uniform curvilinear shape without circumferential welds, and with not more than one longitudinal weld for each 10 inches of pipe diameter. Bellows shall be multi-ply construction. Provide internal/external guides welded to the inner end of pipe and outer cover to guide bellows movement and prevent flow induced vibration. The guides and the cover shall be designed to serve as a limit stop in the event of anchor failure at design conditions. Provide a carbon steel external cover rated for the design conditions of the joint. Provide a 3000 LB, forged steel, ASTM A105, 2 inch socket welded half coupling with a forged steel pipe plug on the cover at the 6 o'clock position to serve as a steam trap/liquid drain.
4) Nameplate: Provide a weatherproof, temperature proof, metal nameplate on the exterior of each expansion joint with all of the following information etched or depressed into the metal: manufacturer, model number, serial number, year fabricated, maximum pressure and temperature rating, design compression and extension of joint, and maximum design full pressure/temperature cycles of the joint.
5) Buttweld end connections are preferred because the externally pressurized joints have a long life and having no flanged connections reduces the chance of leaks.

6) Acceptable Manufacturers: Adsco and Hyspan.
7) All expansion joints shall be provided with a minimum of 5 year warranty against leaks for material defects which shall cover the material replacement. Repair of joint is not acceptable.

3. Ball Joints

a. The use of ball joints is acceptable where connecting into existing piping systems that have a significant amount of movement or other means of compensating for expansion is not feasible.

b. When using ball joints, two joints are usually required per location. Review this carefully and be able to justify only one ball joint to Yale Utilities if you are proposing just one.

c. Specifications

1) Joints shall permit 360 degree rotation and 15 degree minimum total angular flex.
2) Materials:

a) Casing: Carbon steel.
b) Retainer: Carbon steel. Shall be bolted to allow correct seal ring adjustment and disassembly.
c) Ball: Carbon steel. Shall be plated with chrome and shall be lubricated with baked-on molybdenum disulfide.
d) Sealing: The sealing system shall consist of precision machined or molded inner and outer rings, and factory injected sealant. Sealant shall be rated for 300 PSIG saturated steam conditions. Non-metallic seals shall be factory seated with 50 PSIG saturated steam or equivalent thermal conditions. Sealant may be replenished in service while in operation through integral recharges cylinders which shall incorporate a stainless steel shut-off valve.

3) Connections: Flanged ends are preferred because they may require replacement more frequently than externally pressurized joints.
4) Nameplate: Provide a weatherproof, temperature proof, metal nameplate on the exterior of each expansion joint with all of the following information etched or depressed into the metal: manufacturer, model number, serial number, year fabricated, maximum pressure and temperature rating, and angular flex.
5) Acceptable Manufacturers: ADSCO Manufacturing Corporation, Hyspan, Senior Flexonics, or approved equal.
6) Joints shall be provided with a five year minimum warranty against leaks for material defects which shall cover the material replacement. Repair of the joint is not acceptable. In the event of leakage at the stuffing box, spare packing plugs shall be furnished at no charge for a period of five years.

4. Insulation Blankets for Expansion Joints

Blankets are not required for externally pressurized joints – just insulate over the body and leave space on the pipe side where it will expand into the joint. For all other styles of expansion joints, provide the following:

a. Provide insulation blankets for all expansion joints.

b. Provide non-porous inner and outer jackets rated for flooding conditions, constructed of minimum 20 ounce per square yard PTFE Teflon film laminated/impregnated Nomex woven cloth. Blanket construction shall be a double woven stitch with a minimum of 7 stitches per inch. No raw cut jacket edges shall be exposed.

c. Insulation shall be 2 inch thick fiberglass needled mat with minimum 11 lb./ft. Density. All materials shall be rated for service of 450 degrees F. Outer jacket wall temperature shall be less than 120 degrees F. Submit proof of outer temperature assuming wet conditions.

d. Bellows Style: Blanket design shall encase the unit to be insulated and provide a minimum 4 inch overlap extension over insulation of adjacent piping at cold conditions.

e. To accommodate leaks and detect their origins, blanket pieces shall have either a low point drain grommet or a mating seam at the low point which will allow water to seep through.

f. Provide means of prevention of shifting of insulation filler.

C. EXPANSION LOOPS

1. General

a. When expansion loops are used for thermal stress analysis, they must be explicitly stated on the drawings so that the Contractor is aware of their purpose. Provide dimensions on the drawing or specifically designate the expansion loop.

b. Since guide placement is critical for expansion loops, indicate all guide locations.

c. Locate all pipe supports for vertical expansion loops since they can greatly affect the loop performance.

d. It is encouraged to use a thermal stress analysis program to determine expansion loop sizes as opposed to charts or tables that do not take into consideration all the factors of a design.

D. ANCHORS

1. General

a. Anchors shall be designed and detailed on the drawings including stanchions, connections to walls and floors, and connections to the pipe.

b. Do not use pre-insulated anchors for any system. Anchors shall be welded to the piping.

E. GUIDES

1. General

a. All guides shall be purchase, pre-fabricated items from a company that specializes in the design and fabrication of such components in accordance with piping codes. They shall not be made by a Contractor.

b. Guides shall be welded to steam and condensate piping systems. Pre-insulated guides may be used for chilled water systems.

c. If slides are used for pipe supports, the guide style shall be a slide style as opposed to a spider guide style.

d. Spider style guides shall not be considered to hold the weight of the pipe so ensure that adequate pipe supports are located adjacent to spider guides. Slide-style guides can support vertical weight.

F. SUPPORTS

1. General

a. Supports provide vertical load and consist of rollers, slides, or springs. Roller-style supports are preferred. Provide a pipe saddle tack welded to the pipe and insulate inside the saddle.

b. The spacing of supports shall be in compliance with ASME B31.1 and shall not exceed the following:

Nominal Pipe Size (IN)	Maximum Span (FT)
1 to 2	8
2- 1/2 to 3	10
4 to 8	15
10 and over	20

c. Supports shall be tack welded to the piping for steam and condensate piping.

d. For chilled water supports, provide pre-insulated supports or provide rollers under cellular glass insulation system. Do not provide pipe saddles, clamps, or any other attachment to the pipe wall that will be hard to insulate and seal to protect from vapor touching the cool pipe and condensing.

11. PIPING INSULATION

A. GENERAL

1. Installation Notes

a. General: Install insulation material with smooth and even surfaces. Unless otherwise specified, install insulation materials, accessories, and finishes in accordance with the manufacturer's published recommendations. All components of the piping systems shall be insulated including valves, strainers, and all other components.

b. Fire Precaution: Care shall be exercised by the Contractor that no cutting, welding, or open flames are permitted in the areas where flammable mastics or other materials are used. The precaution period shall extend until the material has cured sufficiently so that no further fire hazard exists.

c. Insulation Release: Before insulation is applied to any piping or equipment, the Contractor shall obtain from the Designers a written release stating that the item is ready for insulation.

d. Manufacturer's Recommendations: All materials specified herein shall be installed in full accordance with the manufacturer's recommendations for the best performance and durability of his product, notwithstanding any requirements or omissions herein with respect to preparation of equipment before insulating or method of application.

e. Expansion Joints In Insulation: Where necessary, the Contractor shall furnish suitable expansion joints in the insulation to prevent cracking or wrinkling due to expansion and contraction of the surface being insulated.

f. Surface Condition: Do not apply insulation materials until all surfaces to be covered are clean and dry, all foreign materials, such as rust, scale, and dirt have been removed, and surfaces have been painted. Insulation shall be clean and dry when installed and during the application of any finish.

g. Moisture and Vapor Seal: Provide complete moisture and vapor seal wherever insulation terminates against metal hangers, anchors and other projections through insulation on cold surfaces for which a vapor seal is specified.

h. Asbestos Containing Material: No Contractor, Subcontractor, or Supplier shall furnish any asbestos containing material.

2. Piping Insulation Installation

a. All sectional pipe insulation shall be applied with staggered girth joints tightly butted together as recommended by the insulation manufacturer. Each section of insulation is to be held in place with separate loops of 16 gauge annealed stainless steel wire placed not more than 12 inches on center.

b. Insulation shall not be applied to any flanged, machined, or welded surfaces until they have passed all field tests, including hydrostatic, and have been released for insulation.

c. Insulation of Valves:

1) For all valves (no matter what size) in all locations, the blanket shall cover the body and shall not include the valve bonnet.
2) In all insulated lines, except for those items insulated with blankets, the valve bodies, fittings, and flanges shall be insulated with the same material and the same thickness as the pipe insulation using mitered pipe insulation and/or block insulation securely cemented together. All flange insulation shall be the removable type, but not the replaceable type.

d. Do not insulate steam traps and unions upstream and downstream of steam traps.

e. Gaps and Terminations: Neatly terminate all insulation at each end of unions and at other points where required and seal. Fill gaps occurring at hangers with insulating cement and finish flush with the adjoining pipe insulation as specified for fittings.

f. Wall and Floor Openings: Install insulation and coating of jackets continuous through wall and floor openings.

g. Butt pipe insulation against pipe hanger insulation inserts. For cold piping apply wet coat of vapor barrier lap cement on butt joints and seal joints with 3 inch wide vapor barrier tape or band.

3. Equipment Insulation Installation

a. Insulation Supporting Clips and Other Components: Where insulating clips, supports, angles, studs, washers, etc., are not furnished with the equipment, the Contractor shall furnish and install them. The necessity for location of, quantity, and manner of application shall be as approved by the Engineer.

b. Insulation Over Irregular Surfaces: All irregular surfaces, heads, outlets, nozzles, and fittings shall be insulated with the same material and the same thickness as specified for the tank or equipment of which they are a part. Where necessary, the designated insulation shall be applied in a plastic form and trowelled to a smooth finish.

c. Removable Manhole and Handhole Covers: Removable covers shall be so arranged with insulation stop rings, tapered insulation, etc., that they can readily be removed without disturbing the insulation or its finish. Such removable sections need not be of the type which after having been removed can be installed.

d. Corner Trim for Insulation Finish: Where necessary, the Contractor shall furnish and install metal corner bead and expansion base screen, secured to the poultry wire netting, to obtain a uniform thickness and workmanlike, quality installation.

B. STEAM AND CONDENSATE

1. Tunnels and Buildings

a. Shall be fiberglass, preformed insulation in compliance with ASTM C 547, Class 1, rigid insulation. Thermal conductivity according to ASTM C 335 shall have a minimum of 0.24 BTU-in/hr-sq. ft. deg F at 100 deg F mean temperature and below 0.29 -in/hr-sq. ft. deg F at 200 deg F mean temperature. Insulation shall conform to ASTM C 795. Insulation shall be rated for continuous temperatures to 850 deg F.

b. Insulation Thickness

1) HPS and HPR

Nominal Pipe Size (IN)	Insulation Thickness
3/4” and below	1-1/2”
1” to 1-1/2”	2”
2” to 2-1/2”	2-1/2”
3” to 4”	3”
6”	3-1/2”
8” to 10”	4”
12” to 18”	4-1/2”

2) MPS and MPR

Nominal Pipe Size (IN)	Insulation Thickness
3/4” and below	1”
1” to 1-1/2”	1-1/2”
2” to 2-1/2”	2”
3” to 4”	2-1/2”
6” to 10”	3”

3) LPS and LPR

Nominal Pipe Size (IN)	Insulation Thickness
2” and below	1”
2-1/2” to 4”	1-1/2”
6” to 8”	2”
10” to 18”	2-1/2”

4) PC

Nominal Pipe Size (IN)	Insulation Thickness
6” and below	1”
8” to 18”	1-1/2”

c. Acceptable Manufacturers: Johns-Mansville, Owens Corning, or Knauf.

d. Insulation jacket shall be PVC jacket as follows:

1) Covering shall be produced from white, glossy, high impact, polyvinyl chloride compound such as Johns Manville Zeston® 300 Series PVC or approved equal.
2) Thickness shall be 20 mil. Provide gloss finish.
3) Color to be white to maintain the flame spread and smoke developed rating.
4) Operating temperature shall be rated to 150 degrees F. Flame spread of 25 or less.

Smoke developed rating of 50 or less.

2. Manholes

a. Insulation shall be molded sections of inorganic silicate (calcium or sodium) or expanded perlite. The insulation shall conform to ASTM C533 - Type 1, ASTM C795, and ASTM E84 (0 Flame, 0 Smoke). The calcium silicate shall have a maximum service temperature of 1200 deg. F, a density of 14 LB per cubic foot, and a thermal conductivity of 0.67 BTU-in/hr-sq. ft. deg F. at a mean temperature of 700 degrees F per ASTM C335. Linear shrinkage shall be less than 1%. The insulation shall be certified by the manufacturer not to accelerate stress corrosion of stainless steel pipe and shall conform to ASTM C795.

b. Insulation Thickness

1) HPS and HPR

Nominal Pipe Size (IN)	Insulation Thickness
3/4” and below	1-1/2”
1” to 1-1/2”	2”
2” to 2-1/2”	2-1/2”
3” to 4”	3”
6”	3-1/2”
8” to 10”	4”
12” to 18”	4-1/2”

2) MPS and MPR

Nominal Pipe Size (IN)	Insulation Thickness
3/4” and below	1”
1” to 1-1/2”	1-1/2”
2” to 2-1/2”	2”
3” to 4”	2-1/2”
6” to 8”	3”
12” to 18”	3-1/2”

3) LPS and LPR

Nominal Pipe Size (IN)	Insulation Thickness
2” and below	1”
2-1/2” to 4”	1-1/2”
6” to 8”	2”
10” to 18”	2-1/2”

4) PC

Nominal Pipe Size (IN)	Insulation Thickness
6” and below	1”
8” to 18”	1-1/2”

c. Jacket

1) Insulation jacket shall be weatherproof aluminum. The jacket shall be manufactured from aluminum alloy 5005 or 3003 half hard, not less than 016 inch thick, fabricated with 3/16 inch corrugations running lengthwise of pipeline. The aluminum shall be factory attached to a moisture barrier of kraft paper treated for this service.
2) All joints shall be made rain or drip proof. Longitudinal joints shall be located on

the side of the pipe with the open edge of the lap turned down to shed water. Circumferential joints on pipes that do not have enough slope to get a good shingle effect to keep water out of the joint shall have the inside end of the lap beaded or sealed with a permanently elastic mastic type sealant designed for this service.

3) The aluminum jacket shall be secured by aluminum straps 1/2 inch wide by 0.020 inch thick. The straps shall be placed on 12 inch centers (maximum). Each circumferential joint shall have a strap at the midpoint of the lap.
4) Provide mastic for all insulation on fittings, flanges, valves, and other irregular shaped items on which the aluminum jacket cannot be neatly applied.

C. CHILLED WATER

1. Rigid Cellular Glass Insulation

a. Insulation shall be 100 percent rigid cellular glass, totally inorganic, with no binder. Absorption of moisture shall be 0.2% or less per ASTM C 240. Water-vapor permeability shall be 0.0 perm-in per ASTM E 96. Average compressive strength shall be 90 psi ASTM C 165. Average density shall be 7.5 lb per cubic foot per ASTM C 303. Maximum service temperature shall be 900 degrees F. Thermal conductivity shall be no greater than 0.28 Btu-in/hr-sq. Ft. - degree F at 50 degrees F per ASTM C 177 and ASTM C 518. The insulation shall conform to ASTM E 84 (5 Flame, 0 Smoke). Linear expansion shall be 3 inches per 100 linear feet at 600 degrees F. Insulation shall be fabricated in half sections wherever possible. For large diameter piping where half sections are not practical, curved side wall segments are preferred.

b. Provide insulation from one of the following manufacturers and product trade names:

Pittsburgh Corning FOAMGLAS

800 Presque Isle Drive

Pittsburgh, PA 15239

Phone Number: (800) 359-8433

c. Pipe surfaces shall be clean and dry prior to insulating.

d. Provide PITTSEAL 727 sealant to prevent water vapor entry. Provide PITTCOTE 300 coating to fill the surface cells. Ensure that all pipe surfaces are covered by insulation and that the insulation is sealed and coated so that no condensation takes place on the pipe surface.

e. Insulation shall be temporarily held in place with stainless steel wire or fiber reinforced tape overlapped a minimum of 6 inches prior to the insulation finish being installed. The tape and/or wire may remain on the insulation beneath the insulation finish.

f. Thickness shall be per manufacturer’s recommendations. For tunnels and manholes where steam or condensate piping is present, ambient conditions shall be selected for 120 degrees F and 90 percent relative humidity.

g. Insulation jacket shall be PVC jacket as follows:

1) Covering shall be produced from white, glossy, high impact, polyvinyl chloride compound such as Johns Manville Zeston® 300 Series PVC or approved equal.
2) Thickness shall be 20 mil. Provide gloss finish.
3) Color to be white to maintain the flame spread and smoke developed rating.
4) Operating temperature shall be rated to 150 degrees F. Flame spread of 25 or less.

Smoke developed rating of 50 or less.

D. RE-USABLE BLANKETS FOR VALVES

Provide re-usable blankets for pressure regulating valves.

1. General

a. Insulating material shall be tailor-made removable/reusable blankets. The blankets shall be made with a high temperature fiberglass mat without the use of chemical binders and suitable for temperatures up to 1200 degrees F.

b. All blanket and covers shall be constructed and designed to permit a heat of no more than 92 Btu/sq. ft./hour and a surface temperature of not more than 135 degrees F. in still air at an ambient temperature of 80 degrees F. The minimum blanket insulation thicknesses shall be as follows:

1) Operating Temperature of 130 to 300 degrees F: 1" thick
2) Operating Temperature of 301 to 400 degrees F: 2" thick
3) Operating Temperature of 401 to 500 degrees F: 3" thick
4) Operating Temperature of 501 to 800 degrees F: 4" thick
5) Operating Temperature of 801 to 1000 degrees F: 6" thick

c. Single layer blanket construction may be used for metal temperatures up to 600 degrees F. For metal temperatures over 600 degrees F., double layer construction must be used. The joints for double construction between blankets of the inner layer and those of the outer layer shall be offset from one another.

d. The inner liner material for hot surface temperatures up to 500 degrees F. shall be silicone coated glass cloth, 32 ounce. For hot surface temperatures between 500 and 1000 degrees F., the blanket insulation material shall be enclosed on all sides with a knitted wire mesh. The knitted wire mesh shall be 304 stainless steel wire, 0.11" (11 mils) knitted into a tubular fabric using a mesh size of 60 density.

e. The exterior jacket material shall be silicone glass cloth 32 ounce.

f. All blankets shall be quilted at frequent intervals with quilting fasteners.

g. The blankets shall be made and designed to fit tightly around the outside diameters of the flanges and valves, leaving no gaps when laced. Each blanket shall be constructed with 16 gauge stainless steel wire draw strings that pass through hog rings and are spaced 3/4 inch apart. All mating edges of adjacent blankets shall be fitted with blanket hooks, spaced approximately 6 inches on centers or as required to provide securement for the stainless steel tie wire that are used to lace adjacent blankets together.

h. Where blankets are provided for valves, the cover shall cover the body but not the valve bonnet.

12. PAINTING, PIPING IDENTIFICATION, AND VALVE IDENTIFICATION

A. PAINTING

1. Locations and Style

a. Manholes: Paint vent pipes on the outside of the manhole with color as stated in

Manholes section. Paint style shall be full-gloss alkyd enamel.

b. Tunnels: Paint all steel and supports.

B. PIPING IDENTIFICATION

Provide pipe labels as listed below or paint stencils on piping identifying the service. Identify pipe every 30 feet and in all manholes and mechanical equipment rooms. Include directional arrow. Use identification of systems per the piping specifications with pressures indicated, i.e. HPS250, HPS150, LPC10, PC, CHS, etc.

C. VALVE TAGS

Provide brass valve tags for all manual isolation valves and provide a valve chart for each building, tunnel, and manhole. Valve tags shall begin with the letters of the building or project name, then have the service, and then the number, i.e. SML-HPS-001. Consult with Yale Utilities prior to beginning numbering to ensure that numbers are not repeated.

13. FLOW METERS

A. GENERAL

The accurate measurement of utility flows is important for the University to track usage and can be used for billing. In all cases, follow the manufacturer's required upstream and downstream straight run pipe requirements. Ensure that meters are accurately sized and consider turndown for accuracy. Obtain required flow (minimum and maximum) from Yale Utilities. Systems Engineering provides engineering support of the Yale Office of Facilities. Yale Systems Engineering is responsible for project reviews, design and project management of utilities controls and automation systems, and development of real-time energy metering systems for the University. All flow meter related work shall be in accordance with Yale Systems Engineering and all work in the field shall be coordinated with this department. All flow meters shall be provided with factory calibrated sheets to Yale Systems Engineering for verification that they were tested prior to shipping. All flow meters that do not inherently communicate via the Modbus protocol shall be provided with a modbus converter. This converter shall be configured by contacting Yale Systems Engineering to coordinated register mapping into the existing campus metering system.

B. STEAM

1. General

Steam meters shall be either V-Cone or ultrasonic with pressure and temperature compensation and similar design pressure and temperature conditions as specified below. Others may be added as testing is completed. Refer to Detail (SFM) , Steam Flow Meter for some general details.

2. V-Cone Flow Meters

a. General: The Contractor shall provide a V-Cone type flow meter, based on the principles of differential pressure flow measurement. The meter shall incorporate pressure and temperature flow compensation.

1) Provide a pre-engineered and fully designed package including the V-Cone meter, differential pressure transmitter, gage pressure transmitter, resistance thermocouple device (RTD), and flow computer to provide pressure and temperature

compensated mass steam flow. The signal out of the flow computer shall be 4 to 20 mA linearized mass flow. The pressure and temperature signals with the meter shall not be connected to the DCS or building automation system. The differential and gage pressure transmitters shall be industrial meters, smart devices per Hart protocol, and shall comply with the transmitters specified elsewhere in this SCUDG.

2) A complete system shall include a close-coupled 3-way valve isolation manifold connected by close nipples attached to the V-cone primary flow element to isolate the sensing line from the differential pressure transmitter. The isolation manifold shall be a 316 stainless steel block type. In addition, the system shall include three valve manifold equalizer lines, two block valves, two condensate pots with vent valves, two condensate legs, and two vent and drain valves. No integral pulsation damper shall be required.
3) The V-Cone flow meter shall consist of a V-Cone conical type element positioned in the center of the flow tube to reshape the upstream fluid velocity profile, reducing upstream/downstream piping requirements, allowing greater turndown range ability, and creating a region of low pressure downstream of the cone.
4) Primary elements with rotating and/or moving parts, and/or sudden constructions, are not acceptable.
5) The pressure difference between the static line pressure upstream of the cone and the low pressure area created after the cone shall be measured via two pressure taps that will resist plugging. Low pressure will be sensed through the cone in the center of the line. The pressure taps shall be positioned upstream of the cone element, and spaced an appropriate distance apart to properly ensure orderly connection with the 3-way valve isolation manifold via pressure sensing tubing.
6) The flow tube shall be rotated around the x-axis during installation so that the pressure sensing ports shall resist air entrapment and sediment build-up. At zero flow conditions the static pressure of the high and low pressure ports shall be equal.

b. Design Requirements:

1) Primary Flow Element: The primary flow element shall be designed to re-profile and flatten the fluid velocity profile from any turbulent flows, minimize permanent head loss, reduce upstream and downstream straight meter run requirements, and minimize wear of the conical element.
2) The piping system shall have a minimum straight run of pipe upstream of the meter of fifteen diameters, and a minimum straight run of pipe downstream of the meter of ten pipe diameters.
3) The primary flow element shall be essentially "maintenance free" and corrosion resistant so that no primary element no recalibration over the life of the meter is required.
4) Primary flow element accuracy shall be up to 0.5% of actual flow rate of reading.
5) Primary flow repeatability shall be 0.1% for all calibrated units.
6) The flow meter system with the specified accuracy and repeatability shall have a turndown of 10:1 with a single DP transmitter including a calibration curve fit.

c. Meter Body

1) The meter shall be a precision meter tube style. The precision tube style meter shall be comprised of a cylindrical section, containing a high pressure tap, and include a conical shaped primary flow element incorporating the low pressure tap.
2) The cone and pressure taps shall be 304 stainless steel. The flow tube and flanges

shall be carbon steel.
3) End Connections shall be flanged.

d. Calibration: Calibrate electronics in factory. Provide factory calibration certificate for each meter.

e. Acceptable Products: Provide a V-Cone meter from McCrometer with Rosemount 3051 differential pressure transmitter, Rosemount 3051 gage pressure transmitter, Rosemount 0068R RTD, and KEP Supertrol Flow Computer.

3. Ultrasonic Flow Meters

a. General: Provide ultrasonic style flow meter with electronics for the specific conditions of each meter. The meter shall have no moving parts. Isolation valve feature shall not be provided. The meter shall be microprocessor based, utilizing the Correlation Transit Time flow measuring technique employing coded burst transmission in conjunction with digital signal processing and cross correlation techniques. The meter shall utilize transit time difference of upstream and downstream ultrasonic signals. The meter shall cause no pressure drop. The meter shall have the ability to measure bidirectional flow.

b. Flow Element: Meter shall be wetted instrument in set of flanges. The meter shall incorporate single path single traverse (SPST) liquid ultrasonic flow cell assembly including transducers, designed to ASME Standards. The meter body shall be carbon steel, Schedule STD pipe, with ASME B16.5 Class 300 weld neck flanges. The body shall have one coat self-priming epoxy paint rated to 450 degrees F. The transducer ports and transducers shall be rated for the design pressure and temperature conditions. Transducers shall be pre-installed. Transducers shall be 316 stainless steel. Provide integrated cable for connection of transducer to electronics.

c. Performance:

1) Accuracy: Shall be +/- 1% of reading for flow rates with Reynolds Number of 20,000 or greater, and +/- 2% of reading for flow rates with Reynolds Number of 5,000 to 20,000.
2) Repeatability: +/- 0.2 to 0.5% of reading
3) Rangeability: 150:1
4) Response Time: Less than 5 seconds on any rate change.
5) Permanent Pressure Loss: Shall be no more than 1.0 PSIG at specified maximum flow.

d. Electronics:

1) Output signal shall be 4 to 20 mA for line sized flow. Interface electronics provided with the meter. In addition, provide totalizer, alarms, and Modbus TCP.
2) Local Display: Required. Provide external keypad, multi-key tactile membrane. Display shall be 2 independent software configurable backlit LCD graphical displays.
3) Electronics Housing: Low copper aluminum alloy with epoxy powder-coated finish rated for shall be NEMA Type 4X.
4) Calibration: Calibrate electronics in factory. Provide factory calibration certificate for each meter.

e. Acceptable Products: Provide ultrasonic flow meter from GE Panametrics, Model GS868.

C. CONDENSATE

1. Ultrasonic Flow Meters

a. General: Provide ultrasonic style flow meter with electronics for the specific conditions of each meter. The meter shall have no moving parts. Isolation valve feature shall not be provided.

b. Installation: Flow meter must be installed in a flooded pipe. Refer to Detail 13-2, Typical Condensate Meter Installation (COCBUMS1) and Detail 13-3, Alternate Condensate Meter Installation (COCBUMS2).

c. Flow Element: Meter shall be wetted instrument in set of flanges. The meter shall incorporate single path single traverse (SPST) liquid ultrasonic flow cell assembly including transducers, designed to ASME Standards. The meter body shall be carbon steel, Schedule XS pipe, with ASME B16.5 Class 150 weld neck flanges. The body shall have one coat self-priming epoxy paint rated to 450 degrees F. The transducer ports and transducers shall be rated for the design pressure and temperature conditions. Transducers shall be pre-installed. Transducers shall be 316 stainless steel. Provide integrated cable for connection of transducer to electronics.

d. Performance:

1) Accuracy: Shall be +/- 1% of reading for flow rates with Reynolds Number of 20,000 or greater, and +/- 2% of reading for flow rates with Reynolds Number of 5,000 to 20,000.
2) Repeatability: +/- 0.2% of reading
3) Response Time: Less than 5 seconds on any rate change.
4) Permanent Pressure Loss: Shall be no more than 1.0 PSIG at specified maximum flow.

e. Electronics:

1) Output signal shall be 4 to 20 mA for line sized flow. Interface electronics provided with the meter.
2) Local Display: Required. Provide external keypad.
3) Electronics Housing: Low copper aluminum alloy with epoxy powder-coated finish rated for shall be NEMA Type 4X.
4) Calibration: Calibrate electronics in factory. Provide factory calibration certificate for each meter.

f. Acceptable Products: Provide ultrasonic flow meter from GE Panametrics.

D. CHILLED WATER

1. General

a. Chilled water flow meters shall be clamp-on style per the specifications below. Controlotron and Panametrics are acceptable for the CPP distribution. At this time, only Controlotron is the only acceptable meter for the SPP distribution system. Refer to Yale Systems Engineering to determine if Panametrics is acceptable for the CPP distribution system.

b. Chilled water flow meters have been detailed per the Central Building Utilities Metering Systems (CBUMS). The flow meters are detailed per Detail 13-4, Typical Chilled Water Flow Meter & Chilled Water PCV Stations (CWCBUMS6) and Detail 13-5, Energy Flow Meter (FWM).

2. Sample Specification for Controlotron Clamp-On Meter

   a. The furnished energy flowmeter shall be of a ruggedized clamp-on design with fully integrated energy/BTU calculation utilizing precision matched 1000 Ohm platinum RTD pairs to within 0.02 degrees F and four-wire temperature cable directly linked to the energy flowmeter. In addition, the flowmeter shall be digital microprocessor based utilizing both the Transit-Time flow measuring technique employing a multiple pulse type signal in conjunction with multiple frequency transmission & axial beam transducer technology and Doppler Fourier (Reflexor mode) to insure operation on liquids with and without solids and or bubbles. Wetted flow transducers or electrodes, or flow and temperature measuring techniques other than previously described will not be acceptable.

   b. The energy meter must use Hi-precision transducers, frequency matched to the pipe material and wall thickness utilizing the pipe wall as a waveguide and creating a coherent wide-beam transmission into the liquid. Shear mode or narrow beam transducers will not be acceptable.

   c. The energy meter shall provide automatic transducer spacing, automatic Reynold's Number and liquid sonic velocity variation compensation and live zero flow measurement. The energy meter shall have the ability to indicate energy/BTU rate, volumetric flow rate, flow velocity, total energy, total flow, supply temperature, return temperature, differential temperature, signal strength, liquid sonic velocity, liquid aeration/cavitation and Reynolds Number.

   d. The energy meter shall have internal memory of at least 1 megabyte for data logging purposes and the ability to store application data for over 1000 separate sites. Downloading data logger information to PC's will not require proprietary software but instead will utilize standard "off-the-shelf" software like Windows Terminal program and will allow bi-directional digital communication with full control from the PC. In addition, the energy meter shall provide self and application diagnostics to isolate any fault conditions due to either equipment failure or abnormal process conditions.

   e. The energy meter shall be powered by 90 – 250 VAC, 50/60 Hz. The system shall provide isolated 4 to 20 mADC outputs (one per channel) assignable to energy/BTU rate, flow rate, flow velocity, supply temperature, return temperature, differential temperature, liquid sonic velocity, signal strength, or aeration/cavitation level. In addition, the system shall provide TTL level alarm outputs, RS-232 serial output, and a separate test port for diagnostic and calibration functions. The energy meter shall connect to a separate Modbus protocol converter module supplied with each energy meter. This controller communicates via RS-485. All variations of energy meters shall have a different configuration file and parsing instruction list programmed into the Modbus protocol converter. This may be accomplished either in the field by a qualified field engineer, or at the manufacturing facility prior to delivery.

   f. The energy meter shall have an accuracy of ±1 to 2% of flow over a ±40-fps flow range. Accuracy can be improved to ±0.1 to 1% of flow (depending on application) with wet flow calibration via weight tank method. Repeatability shall be 0.1% of flow with a flow sensitivity of 0.001 fps at any flowrate including no flow conditions. Time measurement resolution shall be in picoseconds to assure proper measurements at low flows. Nanosecond resolution will not be acceptable.

   g. The energy meter shall also possess the following capabilities.

1) Cavitation and Aeration Detection
2) Internal Pipe wall Build-up Detection
3) Liquid Interface Detection
4) Simultaneous Measurement (Dual channel) of Two Separate Pipes
5) Summing of the Flow of Two Separate Pipes
6) Difference of the Flow of Two Separate Pipes
7) Average of the Flow of Two Separate Pipes
8) Reflexor Operation of Liquids with high reflective solids content or extreme aeration.
9) FFT Fast Fourier Transform frequency spectrum analysis of signals during Reflexor mode.
10) Security password protection for individual sites.
11) Pipe simulator for system integrity and calibration check out
12) Two external analog inputs for 4 – 20 mA and 0 – 10Vdc to accommodate other parameters (kW, PSI, etc.) for inclusion into the internal data logger. (Must be externally powered)
13) Reverse Flow and Empty Pipe Detection
14) Direct Digital Temperature measurement via precision matched 1000 Ohm Platinum RTD pair and Four-wire cable connection
15) Qualified for Grade B Shock Test to Mil-Std-901C and Vibration Test to Mil-Std-167-1
16) Certified for CE mark (EMI immunity and compatibility standards)
17) Mod Bus interface module and built-in Modern capability
18) Built-in signal shape coherence diagnostic test graph to verify integrity of installation & assure properly matched transducers for application conditions.

h. System Components: The energy metering system shall consist of the following components:

1) Flow Transducer Set (consisting of transducer pair & mounting tracks for each channel)
2) Flow Transducer Cable Set (for each flow transducer pair)
3) Flow & Thermal Energy Metering System Computer (Single & Dual Channel Capability).
4) RTDs (Resistance Temperature Detectors) One Supply and One Return for each measuring point.
5) RTD cables (one for each RTD)
6) Modbus Protocol Converter
7) Instruction Manual (one for Thermal Energy Metering Computer and for Modbus Protocol Converter)
8) Transducer and RTD coupling compounds

i. Flow Transducer

1) High Precision transducers shall be applied to all Chilled Water applications. High Precision Transducers are frequency matched to the pipe material and wall thickness, utilizing the pipe wall as a waveguide to create a coherent wide beam transmission into the liquid. P/N 1011HNFS-___ (part number suffix to be determined by pipe material and wall thickness).
2) Universal transducers may be applied to steam condensate applications wherever necessary. P/N 1011NFPS-___ (part number suffix to be determined by pipe diameter range).

3) High Temperature transducers shall be applied in all applications where temperature exceeds 250 degrees F. P/N 991NMH-___ (part number suffix to be determined by pipe diameter range).

j. Flow Transducer Cables: One pair of RG 62A/U coaxial cable shall be used for each pair of flow transducers to connect to the energy computer. Length will be determined by actual application dimensions.

k. Energy Metering System Computer:

1) The energy metering system computer shall compute and display the following data on a 64 by 256 pixel LCD:

a) Energy and Flow Rate
b) Energy and Flow Total
c) Stripchart/Bargraph
d) Supply, Return, Differential Temperature
e) Transducer Signal Strength
f) Aeration/Cavitation detection
g) Liquid sonic velocity
h) Flow Direction
i) Datalogger Data
j) System Status Alarms

2) The energy metering system shall automatically adjust for changes in application conditions (temperature, pressure, and liquid characteristics) and shall not allow incorrect energy data to be displayed if application conditions are not suitable for proper operation. System status shall be continually displayed on the LCD during operation.

3) The following data outputs shall be available from the energy metering system:

a) Two A to 20 mA outputs (one per channel) Four additional non-powered 4 to 20 mA outputs optionally available.
b) Two 0 to 10 VDC outputs (one per channel)
c) TTL pulse output 0 to 5 KHz (one per channel)
d) Isolated dry contact or mercury-wetted relays (two per channel)
e) Serial Data Output via Modbus Protocol Converter

4) The energy metering system shall be configured to accept externally powered 4 to 20 mA inputs. These inputs can be in the form of pressure, kW, etc. The system shall retransmit this data via the Modbus protocol converter.

l. RTDs (resistance Temperature Detectors): The RTD’s shall be 1000 ohm platinum wire or film with an alpha of 0.00385, matched to within 0.25 ohms of each other. The RTD’s shall be insertion type. The design shall be based on a four wire Thevenan Measurement System that is independent of wire resistance match, wire length, contact resistance, or temperature. RTD’s shall be suitable for use on ambient and high temperature lines up to 450 degrees F and operate accurately and reliably over this entire range of temperature.

m. RTD Cable: RTD cables shall be four wire shielded construction and be supplied terminated to a length specified for the particular application. The lengths of the supply and return cables can differ from each other without the need for recalibration.

n. Modbus Protocol Converter: The modbus converter shall be configured by contacting

Yale Systems Engineering to coordinate register mapping into the Yale Utilities Metering System.

o. Instruction Manual: An instruction manual for the energy metering system and the Modbus Protocol Converter shall be provided with each system or component allowing a person without full technical raining the ability to commission the system.

p. Coupling Compound: Flow transducer and RTD coupling compounds shall be provided. Coupling compounds for high temperature water lines shall be suitable for use at 450 degrees F.

q. The furnished energy metering system shall be Model 1010EDN3 as manufactured by Controlotron of Hauppauge, N.Y. (1-800-275-8479; www.controlotron.com) or approved equal. Approval for an energy metering system, other than the specified system, will be given if the proposed energy metering system meets the specifications as established by the above and upon an actual demonstration of the equipment on the intended application.

3. Sample Specification for Panametrics Clamp-On Meter

a. Fixed Installation clamp-on or wetted Transit-Time flowmeter with built in data logging, energy option, and the ability to add the optional Transflection measurement mode for multiphase fluids.

b. The furnished flowmeter shall be a fixed installation ultrasonic flowmeter. The flowmeter shall be microprocessor based utilizing the Transit Time flow measuring technique employing coded burst transmission in conjunction with digital signal processing and cross correlation techniques.

c. The flowmeter shall provide transducer spacing, and the following diagnostics: Liquid Sound Speed Signal Strength, Transit Time both upstream and downstream, Delta T, Reynolds Number, Signal % of Peak, Theta, Signal Quality upstream and downstream, and Signal Location in the Window. The flowmeter shall have the ability to display, datalog, and record flow rate, flow velocity and total flow in both directions. Rangeability of the meter shall be 400: 1.

d. The flowmeter shall have the ability to store up to 43,000 flow data points as a log. The meter shall have the ability to store up to 10 separ4ate sites that can be recalled. In addition, the flowmeter shall provide self and application diagnostics to isolate any fault conditions to either equipment failure or abnormal process conditions.

e. The flowmeter electronics shall be housed in a rugged NEMA 4X epoxy coated aluminum enclosure with window. The electronics enclosure shall be 14.24” x 1.4” x 5.12” and weight only 11 lbs. The meter shall have two separate backlight displays and keypad with “soft” function keys for entering data. The display shall be capable of producing both numerical and graphical displays. The flowmeter electronics will power all outputs and additional power supplies will not be necessary. It will also have ModBus communication capable of transmitting all o9utputs and diagnostics.

f. The transducers shall be non-intrusive (clamp on) and constructed of plastic and metal. They shall operate at 2.0 MHZ, 1.0 MHZ or .5 MHZ using a shear wave. Transducers sing Raleigh waves are bit acceptable. Each transducer shall be capable of both sending and receiving ultrasonic signals. The transducers shao9uld be supplied with the option of permanent solid couplant installation.

g. 100 Ohm RTD sensors will be supplied for the measurement of supply and return heating/cooling lines. The flowmeter will have the ability to accept the 0-100 Ohm inputs and both display and transmit temperatures of both lines.

h. The furnished flowmeter shall be the Model DF868 with ModBus communication as manufactured by Panametrics, Inc. of Waltham, MA or approved equal.

i. Modbus Protocol Converter: The Modbus converter shall be configured by contacting Yale Systems Engineering to coordinate register mapping into the Yale Utilities Metering System.

E. YALE STANDARD SCHEMATICS FOR CONDENSATE AND CHILLED WATER METERING

1. Scope

This specification provides standard schematics for use on all projects requiring connections to the Yale University Utilities distribution system. The schematics in this specification provide detailed requirements for these applications.

2. General

The project engineer shall use these documents as standard provision on all applicable projects and shall include them in the project documentation. These documents are to be used as hook up diagrams and not piping arrangements. The project engineer shall design piping arrangement drawings, including plans, elevations or sections, and isometrics which are based on these documents. For all projects the engineer shall consult the distribution system drawings and other as built documentation in Plant Engineering.

3. Typical Installation Requirements

Refer to the Details in the supporting documents.

Details	COCBUMS1	-	Typical condensate meter installation
	COCBUMS2	-	Alternate condensate meter installation
	CWCBUMS6	-	Typical chilled water flow meter and chilled water PCV stations
	FWM	-	Energy Flow Meter

F. COMMISSIONING PROCEDURES

1. General

a. All energy meters shall be delivered with Modbus communications protocol and started up by the meter vendor.

b. The meters MUST report to the server (all registers) in an errorless operations for a duration of one month before acceptance by Yale Systems Engineering.

2. Implementation Procedures

a. The meter vendor shall select the best location for the meter and mark the transducer location on the piping.

b. After the mechanical and electrical contractors complete the meter installation and the communications line is activated, the project manager shall call the vendor to start-up the meter.

c. The vendor shall set up the meter and shall test it out locally, from his PC. This shall include validation of the communication module. The vendor shall notify Yale Systems Engineering in time to verify the meter operation locally.

d. The vendor shall validate the telephone connections and verify the validity of data from all registers of the connected meters on the vendor's PC (not the server) at the meter location. This shall be done with the Yale Systems Engineering representative present at the meter location.

e. If there is a problem, Yale Systems Engineering will troubleshoot the communication lines as per the current set-up procedures.

f. If the meter and communication checks out at the meter location, Yale Systems Engineering shall sign off on the meter test protocols from the vendor. This shall commence a month long test operation of the meter.

g. During the month of test operation Systems Engineering shall develop the interface software on the server and shall interface to the meter.

h. Systems Engineering shall set up the driver, database, color graphics, alarms, trends, and reports on the server.

i. The meter shall be operational and reporting to the server for 30 days. During the test operation, the meter vendor in cooperation with Systems Engineering shall fully "debug" the system. They will report any meter related problem to the project manager.

j. If the problem is related to telephone lines, communications software, server, or applications programs, the meter vendor shall not be responsible for expiration of the 30 day limit for testing.

k. If the problem is related to the meters, filed equipment, communications protocols (hardware and software), and meter location, the meter vendor may request extension of the test period by another 30 days. After expiration of the second 30 day test period, the meter vendor shall remove the defective equipment free of charge to the University, if required by the project manager.

l. After the expiration of the test period, the project manage shall formally accept the meter from the vendor. The project manager shall issue a formal letter of acceptance to the vendor.

m. Following formal acceptance by Yale, the vendor shall issue a formal letter with the date of commencement of the warranty period to the project manager and the warranty period begins.

14. CONDENSATE RETURN UNITS AND FLASH TANKS

A. GENERAL

1. Installation Requirements

a. Condensate return units shall be located in all building mechanical rooms and at all low points in the system where pressure in a dedicated return line cannot push the condensate back to a condensate receiver. Locating a condensate return package in a steam manhole must receive approval from Yale Utilities.

b. Ensure that the vent of a condensate receiver goes to atmosphere and to a safe location.

Do not pipe the vent into the mechanical room – a blown steam trap could cause major humidity and temperature issues.

c. Note that all condensate receivers for electric powered systems have overflow pipes. Ensure that there is a floor drain or sump pump that is rated for the temperature that could come out of an overflowing condensate receiver. Ensure that the vent line for the condensate receiver is sized accurately and that the overflow line is piped correctly so that the overflow line doe not act like a vent and cause humidity and high temperature to go into the mechanical room.

d. Steam powered condensate return units (also known as liquid movers) are preferred in tunnels and mechanical rooms of buildings where adequate steam pressure is available. They must have a back-up air compressor that has 40 PSIG air supply so that condensate can be returned during start-up of the steam system when the steam pressure is not available for the motive force for condensate return. The steam powered units are preferred over electric pumps for most applications.

e. The designer shall ensure that condensate receivers are not overpressurized, especially by the pressure from the flash steam. Typical receiver packages that are not the steam powered type are not rated as pressure vessels. A flash tank may be required upstream of the receiver package depending on the design and the flash tank must have a safety relief valve with a set pressure to protect the vessel. The electric powered pump package is specified to have the condensate pumps rated for 250 degrees F service. If this does not occur, a flash tank must be installed on condensate return lines ahead of the condensate receiver to reduce the condensate temperature to a specified pumping temperature of 200 degrees F. Some steam powered packages require steam to be flashed upstream of the unit so provide one when required.

f. All condensate return pumps and liquid movers shall have spring loaded check valves at the discharge as specified in Part 7.

2. Electric Powered Pump Condensate Return Package

a. Acceptable Manufacturers include Shipco, Skidmore, and Spirax Sarco.

b. Description: Factory-fabricated, packaged, electric-drive pump units of capacity indicated. Include receiver, pumps, float switches, controls, control panel, and accessories suitable for operation with specified conditions. Receiver shall be able to receive and flash high pressure condensate.

c. Configuration: Floor-mounting, duplex unit with receiver, 2 centrifugal water pumps, 2 float switches, and connecting piping.

d. Receiver: Typically 21 Gallon (total capacity) but tank size to allow a full discharge flow rate for 1-1/2 to 3 minutes to prevent short-cycling of the pump. Material shall be cast iron – ensure flash tank upstream since tank will not be rated for pressure. Include externally adjustable float switches, water-level gage, one loose pressure gage (for Contractor installation on common discharge header downstream of all isolation valves), dial thermometer, and 2 lifting eyebolts. Shall be full vented to operate at atmospheric pressure. ASME Code stamp not required.

e. Performance: Each pump shall be provided with the following design values:

1) Fluid: Condensate
2) Temp (deg F.): 212
3) Design Flow (gpm): Per the design. Size electric driven condensate pumps for 2-

1/2 to 3 times the amount of condensate returned in one minute.

4) Pump Head (PSIG): Per the design. Ensure that the pump can satisfy the static lift requirements back to the next condensate receiver it is pumping to.
5) Pump Minimum Net Positive Suction Head, NPSH (FT): 2.0
6) Maximum Speed (RPM): 3500

f. Inlet Valves: Shall be provided for each pump, pre-assembled. Shall be butterfly style to reduce head drop.

g. Inlet Strainer: Provide basket style strainers for each pump.

h. Water Pumps: Centrifugal, enclosed vane and precision balanced cast bronze impeller, close coupled, permanently aligned, base mounted. Provide straightening vanes for the axial flow impeller to provide low NPSH. Include enclosed renewable bronze case rings, stainless-steel shafts, and mechanical seals. Flange mount centrifugal water pump on receiver. Provide close-coupled pump, vertical design, permanently aligned, bronze fitted, equipped with stainless steel shaft, enclosed bronze impeller, renewable bronze case ring, mechanical shaft seal, and suction butterfly valve. Seals must be rated for 250ºF. Provide open drip proof motor close coupled to pump. Pump shall be rated for maximum 2' net positive suction head (NPSH) @ 210°F (sea level). (If pumps are not rated for 2’ NPSH, the tank must be elevated on legs to a level where the pumps will not cavitate.)

i. Motor shall be heavy duty ball bearing design, open drip proof and shall be 460VAC, 3-phase, 60 hertz. Provide water safety slingers to prevent the water from entering the motor.

j. Pressure Gage: Provide at discharge of each pump.

k. Overflow: Pipe end shall be located near bottom of receiver with water loop to prevent overflow from acting as a vent. Provide separate vacuum breaker piping external to the tank to prevent the overflow line to act as a siphon.

l. Duplex Pump Control Panel: The condensate return unit manufacturer shall provide a factory-assembled, and UL listed and labeled duplex pump control panel for each pair of pumps. The control panel shall be located in a position that an operator does not require a ladder to access the panel. Where the pump package is in a pit, the control panel shall be located above, outside, and adjacent to the pit. Factory wired for single external electrical connection. The control panel shall be supplied with the following components:

1) NEMA 4X stainless steel enclosure with ANSI 61 light gray exterior and white interior.
2) Three-pole molded case thermal magnetic circuit breaker sized for motor load, with external flange mounted disconnect switch handle. External disconnect switch handle shall be capable of being padlocked in the open position.
3) NEMA rated motor starters with three-pole motor circuit protectors to provide individual motor starter short circuit protection, three-pole magnetic contactors, and Class 10 ambient compensated bimetal overload relays.
4) Control power transformer with primary and secondary fuses, line voltage primary and 120V grounded secondary, with minimum of 50VA additional capacity.
5) Door-mounted HAND-OFF-AUTO selector switch, START pushbutton, STOP pushbutton, RESET pushbuttons for overload relays, red LED MOTOR STOPPED, and green LED MOTOR RUNNING pilot lights for each pump motor.

6) Solid state lead-lag pump alternator with float status lights.
7) Lag pump delay start relay.
8) Alternator shall be suitable for four sump float operation (low level – pumps off, lead pump on, lag pump on, high level alarm). Dry contact shall be provided for remote high level alarm notification.
9) Alternator selector switch to override the lead-lag alternator and allow operation of pump 1 or pump 2 only.
10) 115V anti-condensation heater connected to 120V control transformer. Heater shall be provided with adjustable thermostat and over-temperature control.
11) Local external high level alarm light and horn.
12) 115VAC service light to provide internal panel illumination during service work.
13) Internal 115VAC duplex convenience receptacle.
14) Terminal blocks shall be provided for connection of level controls and other control wiring as required for proper pump installation.
15) Motor starters, relays, and other internally mounted components shall be DIN rail mounted
16) Internal wiring shall be type THHN/THWN/MTW 600 V insulated stranded copper wire
17) Wire between devices shall be neatly routed inside plastic wireway with slots for wiring and snap-on plastic covers
18) Field wiring shall be terminated at insulated tubular barrel terminal strips with compression plates. No more than two wires shall be installed at each terminal
19) Tank float switches shall be mounted from top to bottom in the following order:

    a) High Level Alarm
    b) Lag Pump On
    c) Lead Pump On
    d) Low Level

20) Pump sequence of operation shall be as follows:

    a) Tank empty: Pumps off.
    b) Tank level rises to lead pump float switch: Start lead pump.
    c) Tank level rises to lag pump float switch: Start lag pump.
    d) Tank level rises to high level alarm float switch: Transmit high level alarm to one of the Yale Controls and Alarm Call Center. Contact Yale Utilities Distribution Systems (UDS) for direction and location of alarm termination points.
    e) Shut off pumps when level falls below low level float switch.
    f) Pumps alternate lead and lag for next pump out cycle.

m. Manual Lead-Lag Control: Shall override electric alternator when active pump is manually selected and allow both pumps to operate on receiver high level.

3. Steam Powered Condensate Return Unit (Liquid Mover)

   a. Acceptable Manufacturer is Gestra, Product FPS 14, Steam-Powered Condensate-Return Unit or approved as equal by Yale Utilities Distribution Project Representative.

   b. Description: Factory-fabricated, packaged, steam powered unit of capacity indicated. Unit shall use steam pressure (and compressed air as a back-up) to move condensate to the next condensate receiver downstream. Include receiver and accessories suitable for operation with specified conditions. Receiver shall be able to receive and flash high pressure condensate.

c. Configuration: Floor-mounted. For each location, provide two units so that one serves as a back-up for a lead-lag type configuration. Provide all external piping to allow isolation of one unit to keep the other unit in service.

d. Package: Size of body is dictated by the capacity of the unit. Body shall be cast steel, shall be provided with ASME Sec VIII Code stamp, and the external shall be painted. The package shall include all necessary items for complete operation including steam inlet control valve, float valve of chromium or stainless steel, and check valves for inlet, outlet, and vent – all of these items shall be steel or stainless steel. Include water-level gage with isolation valves and one loose pressure gage and dial thermometer for Contractor installation on common discharge header downstream of all isolation valves. Include drain plug. Float and steam inlet and vent valves shall be accessible through a flanged connection on top of the unit.

e. Performance: Each liquid mover shall be provided with the following design values:

1) Fluid: Condensate
2) Temp (deg F.): 212
3) Design Flow (gpm): Per the design.
4) Pump Head (PSIG): Per the design. Ensure that the pump can satisfy the static lift requirements back to the next condensate receiver it is pumping to.
5) Pump shall use no more than 3 pounds of steam per 1000 pounds of liquid condensate moved.
6) Note that flow and head ability of the equipment are highly dependent on available motive pressure (steam or compressed air). Designers must verify conditions with the manufacturer before specifying.

f. Pressure Switch: Provide a pressure switch and connect to each liquid mover. The switch shall be rated for steam service to 150 PSIG and shall have a field adjustable range from 5 to 100 PSIG. When the pressure is below the set point and the switch is open, it is assumed that the liquid mover is collecting condensate. When the pressure goes above the set point and the switch closes, it is assumed that the liquid mover is in the pumping stage. Connect each switch to Yale Customer Service Control Center and commissioning the operation of the switch to be per the described logic. This pressure switch will be monitored by Yale Systems Engineering – if the switch does not close after a period of time, it will be assumed that there is something wrong with the liquid mover. Also, the switch can be used by Yale Systems Engineering as a back-up and/or a verification of the condensate return meter.

4. Flash Tanks

a. General

1) Refer to Detail 14-1, Flash Tank.
2) Provide flash tanks for reducing high and medium pressure to low pressure and draining condensate down to a receiver.
3) Flash steam velocity shall be low enough to permit moisture-free steam exiting the tank. Tank diameter shall be minimum of 12 inches.

b. Type and Construction: The flash tank shall be designed and constructed in accordance with the ASME Unfired Pressure Vessel Code and bear the appropriate code symbol. The design pressure shall be 20 PSIG or greater. Flash tank shall be constructed of SA516 Grade 70 Carbon Steel. Hydrostatically test vessel at 1-1/2 times design pressure. New gaskets shall be furnished with the vessel after the test. Equip tank with required wear plates to insure maximum moisture-solids removal and long life. The wear plate shall extend 270 degrees around the internal circumference of the tank.

c. Accessories

1) Safety Relief Valve: Shall have ASME UV stamp for Section VIII vessel. Shall be set for 20 PSIG.
2) Gage Glass: Length shall cover normal operating level plus/minus 6 inches. Provide automatic gage valves which stop the flow if a glass is broken. Provide a drain lock on lower gage valve.
3) Nameplate: Attach to bracket projecting beyond field-applied insulation. This nameplate must include all ASME pressure vessel nameplate information as required by the Code.
4) Support: Steel legs welded to the flash tank. Coordinate location with structural design of building. Support shall facilitate bottom piping connections.
5) Cleaning and Painting: Remove all foreign material to bare metal. Coat exterior of tank with rust-preventative primer. . Do not coat interior of tank.
6) Insulation: Field-applied. Refer to detail.
7) Steam Trap Station: Provide and mount per detail to keep water level in tank.

15. STEAM PRESSURE REDUCING STATIONS AND SAFETY DEVICES

A. GENERAL

1. Type

a. Steam pressure reducing stations shall be Leslie with remote pilot regulators and air assisted valves. The pilot regulator must be remote from the body of the valve and shall be clearly labeled as to what service it is for and shall be installed in a very accessible location. Provide separate mounting brackets and hardware.

b. Alternate manufacturers systems may be proposed only when approved as equal by Yale Utilities Distribution Project Representative.

c. Reducing stations shall be designed for parallel redundancy. Do not provide 1/3 – 2/3 stations. Do not oversize valves.

2. Installation Notes

a. Most steam pressure reducing stations are located in basements. Vent piping from safety relief valves may have to be rather long to safely discharge steam where it cannot harm persons. Discharge within buildings is not acceptable.

b. In lieu of safety relief valves, safety trip valves may be acceptable and must be in accordance with the ASME, the National Board Inspection Code (NBIC).

c. Do not install any safety relief valves open to the campus distribution system. Steam pressures will not exceed the maximum pressures specified in this document and the distribution pressures (both operating and maximum) will not be changed by any new building design. All safety relief valves provided in the steam system shall be installed downstream of a building pressure regulating station and shall protect the building piping and equipment. If a building is designed without a pressure regulating station, all equipment in the building must be rated for the maximum pressure listed in this document and all piping (including thermal stress and support analysis) must consider these conditions.

d. Do not provide by-pass valves around the pressure regulating valves.

e. Provide a union in the air regulator to the pressure regulating valves so they can be disconnected.

16. SUPPORTING DOCUMENTS

A. PART 1

1. Drawing No. 1 - Existing CPP Steam Distribution Network
2. Drawing No. 2 - Existing CPP Chilled Water Distribution Network
3. Drawing No. 3 – Existing SPP Steam Distribution Network
4. Drawing No. 4 – Existing SPP Condensate Return Distribution Network
5. Drawing No. 5 – Existing SPP Chilled Water Distribution Network

B. PART 3

1. Detail 3-1, Link Seals, End Seals, and Gland Seals

C. PART 4

1. Detail 4-1, Typical Steam Manhole Layout with Forced Ventilation
2. Detail 4-2, Typical Steam Manhole Layout with Natural Ventilation
3. Detail 4-3, Vent Coffer Details
4. Detail 4-4, Ladder Detail

D. PART 7

1. Detail 7-1, Steam Drip Leg and Steam Trap Station Details
2. Detail 7-2, Steam Isolation Valve By-Pass Detail

E. PART 13

1. Detail 13-1, Steam Flow Meter (SFM)
2. Detail 13-2, Typical Condensate Meter Installation (COCBUMS1)
3. Detail 13-3, Alternate Condensate Meter Installation (COCBUMS2)
4. Detail 13-4, Typical Chilled Water Flow Meter & Chilled Water PCV Stations (CWCBUMS6)
5. Detail 13-5, Energy Flow Meter (FWM)

F. PART 14

1. Detail 14-1, Flash Tank